UNIT-3

CLASSIFICATION OF ELEMENTS AND PERIODICITY IN PROPERTIES

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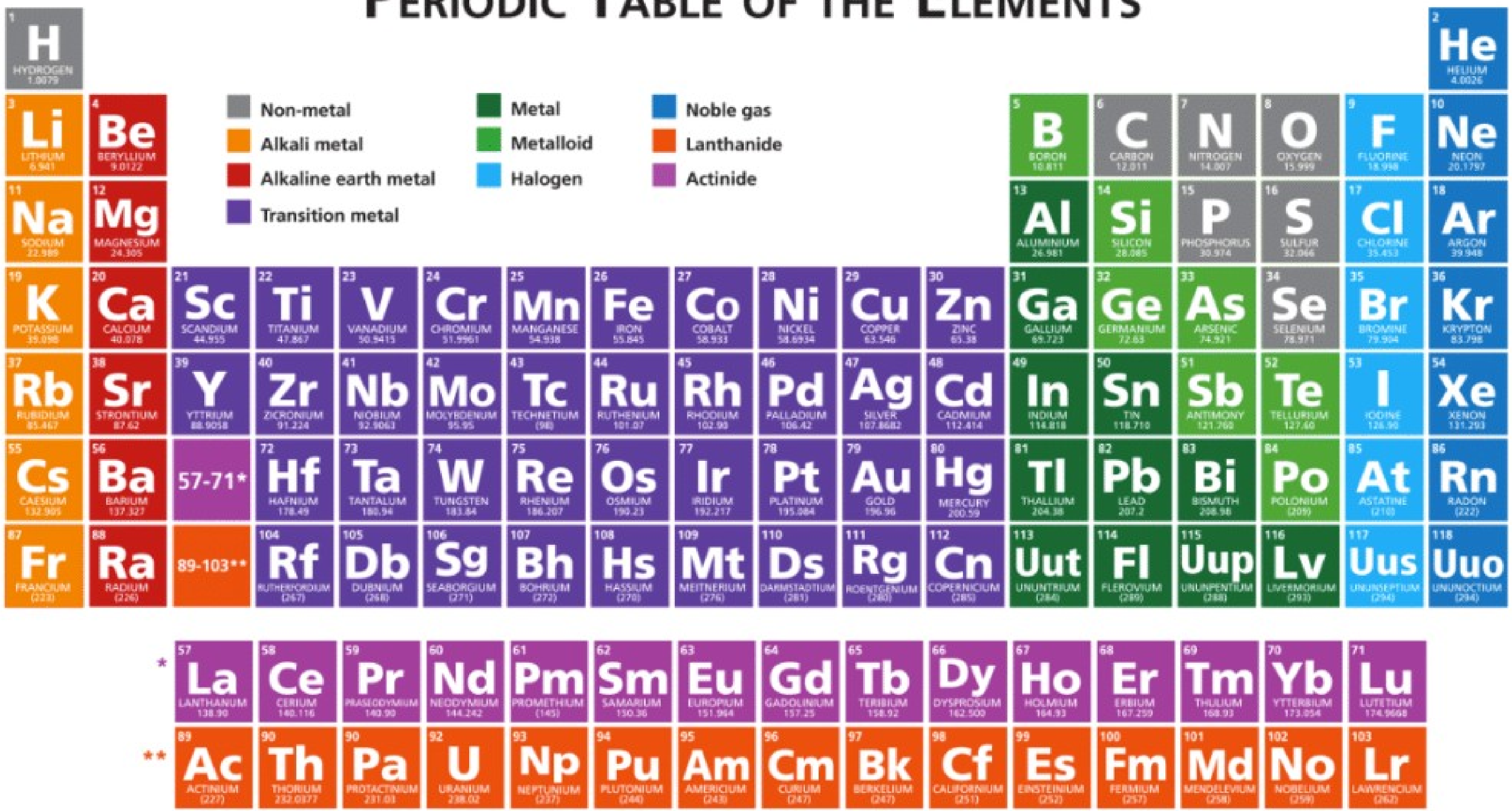
PERIODIC TABLE

An arrangement of all the known elements according to their properties so that similar elements fall within the same vertical column and dissimilar elements are separated.

PERIODIC TABLE OF THE ELEMENTS



EARLIER CLASSIFICATION OF ELEMENTS

CLASSIFICATION OF ELEMENTS

1. DOBEREINER'S LAW OF TRIADS
2. NEWLANDS' LAW OF OCTAVES
3. MENDELEEV'S PERIODIC TABLE
4. MODERN PERIODIC TABLE

DOBEREINER'S LAW OF TRIADS

Johan Dobereiner (1829)

- ✓ **In 1829, Dobereiner arranged the known elements of at that time in the ascending order of atomic masses.**
- ✓ **He found out three elements group called triad.**
- ✓ **In a triad, the properties of the middle elements are the average of the other two.**
- ✓ **This law is known as Dobereiner's law of triads.**

EXAMPLES OF TRIADS

Dobereiner's Triads					
Element	Atomic weight	Element	Atomic weight	Element	Atomic weight
Li	6.9	Ca	40.1	Cl	35.5
Na	23.0	Sr	87.6	Br	79.9
K	39.1	Ba	137.3	I	126.9

NEWLANDS' LAW OF OCTAVES

James Newlands (1865)

- ✓In 1865, Newlands arranged all the known elements of at that time in the ascending order of atomic masses.
- ✓He observed that the properties of the eighth elements are the simple repetitions of the first one like eighth note in an octave in music.
- ✓This law is known as Newlands law of octaves.

John Newlands and his Interval of Eight

Group	A	B	C	D	E	F	G
1	1 H HYDROGEN 1	3 Li Lithium 7	4 Be Berylium 9	5 B Boron 11	6 C Carbon 12	7 N Nitrogen 14	8 O Oxygen 16
2	9 F FLUORINE 19	11 Na Sodium 23	12 Mg Magnesium 24	13 Al Aluminum 27	14 Si Silicon 28	15 P phosphorus 31	16 S Sulphur 32
3	17 CL CHLORINE 35	19 K Potassium 39	20 Ca Calcium 40	24 Cr Chromium 52	22 Ti Titanium 48	25 Mn Manganese 55	26 Fe Iron 56
4	27/28 Co/Ni COBALT/ NICKEL 58/59	29 Cu Copper 64	30 Zn Zinc 65	39 Y Yttrium 89	49 In Indium 115	33 As arsenic 75	34 Se Selenium 79
5	35 BR BROMINE 80	37 Rb Rubidium 85	38 Sr Strontium 88	57/58 La/Ce Lanthanum/ Cerium 139/140	40 Zr Zirconium 91	42 Mo Molybdenum 96	44 Ru Ruthenium 101
6	46 PD PALLADIUM 106	47 Ag Silver 108	48 Cd Cadmium 112	92 U Uranium 238	50 Sn Tin 119	51 Sb Antimony 122	53 I Iodine 127
7	77/78 IR/PT IRIDIUM/ PLATINUM 192/195	76 Os Osmium 190	80 Hg Mercury 201	81 Tl Thallium 204	82 Pb Lead 207	83 Bi Bismuth 209	90 Th Thorium 232

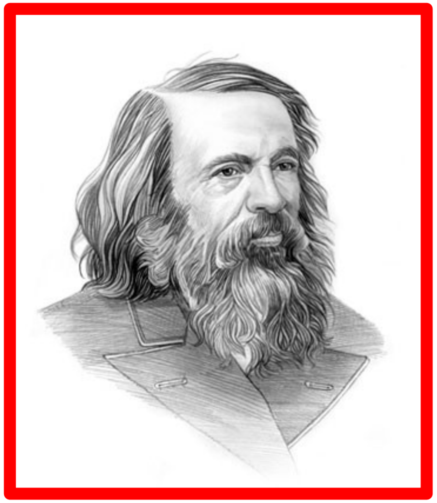
MENDELEEV’S PERIODIC TABLE

Dimitri Mendeleev

- ✓ **In 1869, a Russian chemist Mendeleev arranged the known elements of at that time in the ascending order of atomic masses.**
- ✓ **He observed that same properties are repeated in regular intervals and proposed a law known as Mendeleev’s periodic law.**

MENDELEEV'S PERIODIC LAW

The law states that "the physical and chemical properties of elements are periodic functions of their atomic masses"



Dimitri Mendeleev

NOTE

- ✓ Gallium and Germanium were unknown at the time Mendeleev published his periodic table.
- ✓ He left a gap under aluminium and a gap under silicon.
- ✓ He called these elements Eka-Aluminium and Eka-Silicon.

Periodic Table of Elements
based on Mendeleev's Periodic Law

0	I	II	III	IV	V	VI	VII	VIII		
	H 1.01									
He 4.00	Li 6.94	Be 9.01	B 10.8	C 12.0	N 14.0	O 16.0	F 19.0			
Ne 20.2	Na 23.0	Mg 24.3	Al 27.0	Si 28.1	P 31.0	S 32.1	Cl 35.5			
Ar 40.0	K 39.1 Cu 63.5	Ca 40.1 Zn 65.4	Sc 45.0 Ga 69.7	Ti 47.9 Ge 72.6	V 50.9 As 74.9	Cr 52.0 Se 79.0	Mn 54.9 Br 79.9	Fe 55.9	Co 58.9	Ni 58.7
Kr 83.8	Rb 85.5 Ag 108	Sr 87.6 Cd 112	Y 88.9 In 115	Zr 91.2 Sn 119	Nb 92.9 Sb 122	Mo 95.9 Te 128	Tc (99) I 127	Ru 101	Rh 103	Pd 106
Xe 131	Ce 133 Au 197	Ba 137 Hg 201	La 139 Ti 204	Hf 179 Pb 207	Ta 181 Bi 209	W 184 Po (210)	Re 180 At (210)	Os 194	Ir 192	Pt 195
Rn (222)	Fr (223)	Ra (226)	Ac (227)	Th 232	Pa (231)	U 238				

Dobereiner's triads

Known to Mendeleev

Lanthanide series

Actinide series

Known to Ancients

DEMERTIS OF MENDELEEV'S PERIODIC TABLE

- ✓ Elements with dissimilar properties are found in same group.
- ✓ He could not give an exact position for hydrogen.
- ✓ He could not give exact position for Lanthanoids and Actinoids and also for isotopes.
- ✓ Did not strictly obey the increasing order of atomic weights.

MODERN PERIODIC TABLE

Henry Moseley

- ✓ **Moseley’s work on the x-ray spectra of the elements reveals that atomic number is a more fundamental property than atomic mass.**
- ✓ **On the basis of this, he put forward the modern periodic law.**

MODERN PERIODIC LAW

The law states that “the physical and chemical properties of elements are periodic functions of their atomic numbers”.

PERIODS AND GROUPS

PERIODS

- The horizontal rows present in the modern periodic table are called periods.
- There are seven periods.
- The first period consists of 2 elements.
- Second and third period consists of 8 elements each.
- Fourth and fifth period consists of 18 elements.
- Sixth period consists of 32 elements.
- The last seventh period is an incomplete period.

GROUPS

- ✓ The vertical columns present in the modern periodic table are called groups.
- ✓ There are 18 vertical columns.
- ✓ Therefore 18 groups are present in the modern periodic table.

MODERN CLASSIFICATION OF ELEMENTS

- **In the modern periodic table, elements are classified into four blocks.**
- **They are s, p d and f block elements.**
- **Classification is based on the orbital in which the last electron of the atom of the element enters.**

S-BLOCK ELEMENTS

- The elements in which the last electron enters the s orbital of their valence shell are called s block elements.
- It consists of elements of group 1 and group 2.
- The ground state configuration of the valence shell is ns^1 or ns^2 i.e., (ns^{1-2}).

Chemical elements in s-block

Period \ Group	1	2	18
1	1 H		2 He
2	3 Li	4 Be	
3	11 Na	12 Mg	
4	19 K	20 Ca	
5	37 Rb	38 Sr	
6	55 Cs	56 Ba	
7	87 Fr	88 Ra	

P-BLOCK ELEMENTS

- The elements in which the last electron enters the p orbitals of their valence shell are called p block elements.
- It consists of group 13—18 except He.
- The ground state configuration of the valence shell is $ns^2\ np^1$ to $ns^2\ np^6$.

P - BLOCK ELEMENTS

Groups

13	14	15	16	17	18
					2 He
5 B	6 C	7 N	8 O	9 F	10 Ne
13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
81 Ti	82 Pb	83 Bi	84 Po	85 At	86 Rn

Group - 17 Halogens

Group - 18 Noble Gases

Metals

Metalloids

Non-Metals

d-BLOCK ELEMENTS

- The elements in which the last electron enters the d orbitals are called d block elements.
- It consists of groups 3—12.
- The general electronic configuration is $(n-1)d^{1-10}\, ns^{1-2}$.

d-BLOCK ELEMENTS

scandium 21 Sc 44.956	titanium 22 Ti 47.867	vanadium 23 V 50.942	chromium 24 Cr 51.996	manganese 25 Mn 54.938	iron 26 Fe 55.845	cobalt 27 Co 58.933	nickel 28 Ni 58.693	copper 29 Cu 63.546	zinc 30 Zn 65.38
yttrium 39 Y 88.906	zirconium 40 Zr 91.224	niobium 41 Nb 92.906	molybdenum 42 Mo 95.96	technetium 43 Tc [98]	ruthenium 44 Ru 101.07	rhodium 45 Rh 102.91	palladium 46 Pd 106.42	silver 47 Ag 107.87	cadmium 48 Cd 112.41
lanthanum 57 La 138.91	hafnium 72 Hf 178.49	tantalum 73 Ta 180.95	tungsten 74 W 183.84	rhenium 75 Re 186.21	osmium 76 Os 190.23	iridium 77 Ir 192.22	platinum 78 Pt 195.08	gold 79 Au 196.97	mercury 80 Hg 200.59
actinium 89 Ac [227]	rutherfordium 104 Rf [261]	dubnium 105 Db [262]	seaborgium 106 Sg [266]	bohrium 107 Bh [264]	hassium 108 Hs [277]	meitnerium 109 Mt [268]	darmstadtium 110 Ds [271]	roentgenium 111 Rg [272]	Copernicium 112 Cn [285]

f-BLOCK ELEMENTS

- The elements in which the last electron enters the f orbitals are called f block elements.
- Their general electronic configuration is $(n-2)f^{1-14}(n-1)d^{0-1}ns^{2}$.

f-BLOCK ELEMENTS

57	58	59	60	61	62	63	64	65	66	67	68	69	70	71
138,9	140,1	140,9	144,2	[145]	150,4	152,0	157,3	158,9	162,5	164,9	167,3	168,9	173,1	175,0
La	**Ce**	**Pr**	**Nd**	**Pm**	**Sm**	**Eu**	**Gd**	**Tb**	**Dy**	**Ho**	**Er**	**Tm**	**Yb**	**Lu**
lantani	ceri	praseodimi	neodimi	prometi	samari	europi	gadolini	terbi	disprosi	holmi	erbi	tuli	iterbi	luteci
89	90	91	92	93	94	95	96	97	98	99	100	101	102	103
[227]	232,0	231,0	238,0	[237]	[244]	[243]	[247]	[247]	[251]	[252]	[257]	[258]	[259]	[262]
Ac	**Th**	**Pa**	**U**	**Np**	**Pu**	**Am**	**Cm**	**Bk**	**Cf**	**Es**	**Fm**	**Md**	**No**	**Lr**
actini	tori	protactini	urani	neptuni	plutoni	americi	curi	berkeli	californi	einsteini	fermi	mendelevi	nobeli	lawrenci

TYPES OF ELEMENTS

REPRESENTATIVE ELEMENTS

All the elements of the s and p block elements together constitute the representative elements.

NOBLE GASES

The elements of the 18th group are called noble gases or inert gases or rare gases.

TRANSITION ELEMENTS

- ✓ **The d block elements i.e., elements of group 3—12 are called transition elements.**
- ✓ **They are placed in between s and p block elements.**

INNER TRANSITION ELEMENTS

- ✓ The f block elements are called inner transition elements.
- ✓ It consists of Lanthanides and actinides.
- ✓ The elements coming after Lanthanum are called lanthanides.
- ✓ The elements coming after actinium are called actinides.

CLASSIFICATION OF ELEMENTS INTO METALS, NON METALS AND METALLOIDS

METALS

- ✓ More than 75% of all known elements
- ✓ are metals.
- ✓ Appear on the left side of the periodic table.
- ✓ Usually solids at room temperature.
- ✓ Have high melting and boiling points.
- ✓ Good conductors of heat and electricity.
- ✓ Malleable and ductile.

NON METALS

- ✓ Non-metals are located at the top right hand side of the periodic table.
- ✓ Usually exists as solids or gases at room temperature.
- ✓ Low melting and boiling points.
- ✓ Bad conductors of heat and electricity.

METALLOIDS

- ✓ Metalloids or semi metals are elements which show both the properties of metals and non metals.
- ✓ Eg: Boron, Silicon, Germanium, Arsenic, Antimony, Selinium, Tellurium and Polonium.

NOTE

- ✓ **The metallic character increases from top to bottom of a group.**
- ✓ **Non metallic character increases from left to right across a period.**

NOMENCLATURE OF ELEMENTS WITH ATOMIC NUMBER GREATER THAN 100

- ✓ The elements are named using the numerical roots for 0 and numbers 1-9.
- ✓ The roots are put together in the order of digits which make up the atomic number.
- ✓ 'ium' is added at the end.

The IUPAC names for the elements with Z above 100 are shown below.

Digit	Name	Abbreviation
0	nil	n
1	un	u
2	bi	b
3	tri	t
4	quad	q
5	pent	p
6	hex	h
7	sept	s
8	oct	o
9	enn	e

Atomic Number	Name according to IUPAC nomenclature	Symbol	IUPAC Official Name	IUPAC Symbol
101	Unnilunium	Unu	Mendelevium	Md
102	Unnilbium	Unb	Nobelium	No
103	Unniltrium	Unt	Lawrencium	Lr
104	Unnilquadium	Unq	Rutherfordium	Rf
105	Unnilpentium	Unp	Dubnium	Db
106	Unnilhexium	Unh	Seaborgium	Sg
107	Unnilseptium	Uns	Bohrium	Bh
108	Unniloctium	Uno	Hassium	Hs
109	Unnilennium	Une	Meitnerium	Mt
110	Ununnillium	Uun	Darmstadtium	Ds
111	Unununnium	Uuu	Rontgenium	Rg
112	Ununbium	Uub	Copernicium	Cn
113	Ununtrium	Uut	Nihonium	Nh
114	Ununquadium	Uuq	Flerovium	Fl
115	Ununpentium	Uup	Moscovium	Mc
116	Ununhexium	Uuh	Livermorium	Lv
117	Ununseptium	Uus	Tennessine	Ts
118	Ununoctium	Uuo	Oganesson	Og

PERIODIC PROPERTIES

Properties which are directly or indirectly related to the electronic configuration of the elements and show a regular gradation when we move from left to right across a period or from top to bottom in a group are called periodic properties.

IONISATION ENERGY

- ✓ Ionisation energy is also known as Ionisation Potential.

- ✓ The minimum amount of energy required to remove the most loosely bound electron from an isolated gaseous atom.

$$M_{(g)} + IE \rightarrow M^{+}_{(g)} + e^{-}$$

- **The energy required to remove the first electron is called first Ionisation energy (IE_1).**
- **The energy required to remove the second electron is called second ionisation energy (IE_2).**
- **In general, $IE_2 > IE_1$.**

FACTORS INFLUENCING IONISATION ENERGY

1. ATOMIC SIZE

The larger the atomic size, smaller the ionisation energy.

Smaller the atomic size, larger the ionisation energy.

2. NUCLEAR CHARGE

Ionisation energy increases with increase in nuclear charge.

3. SHIELDING EFFECT

- ✓ The inner electrons repel the outer electrons and cut down the attractive force between the nucleus and the valence shell.
- ✓ This effect is known as shielding effect or screening effect.
- ✓ As the shielding increases the ionisation energy decreases.

4. EFFECT OF HALF FILLED AND COMPLETELY FILLED SUB SHELLS

If an atom has half filled or completely filled sub shells, its ionisation energy is higher than that expected from its position in the periodic table.

ELECTRON AFFINITY

The energy released when an isolated gaseous atom changed into an anion by accepting an electron.

$$X_{(g)} + e^{-} \rightarrow X^{-} + \text{Energy}$$

FACTORS INFLUENCING ELECTRON AFFINITY

1. ATOMIC SIZE

Larger the size of the atom, the smaller will be the electron affinity and vice versa.

2. NUCLEAR CHARGE

Greater the nuclear charge, greater the electron affinity.

3. ELECTRONIC CONFIGURATION

- ✓ When the electronic configuration of the atom is stable, the less will be the tendency of the atom to accept an additional electron and hence lower will be the electron affinity.
- ✓ The electron affinity values of halogens are very high because of their strong tendency to accept an electron to attain the stable noble gas configuration.

3. ELECTRONEGATIVITY

The tendency of an atom to attract the shared pair of electrons towards itself.

- ✓ **Small atoms are more electronegative because they attract electrons more strongly than the larger ones.**
- ✓ **Atoms with nearly filled shells will have higher electronegativities than those with less densely filled ones.**
- ✓ **NOTE: The least electronegative element is cesium and the most electronegative element is fluorine.**

SCALES OF ELECTRONEGATIVITY

- ✓ Most commonly used scales are
- ✓ Pauling’s Scale
- ✓ Mulliken’s Scale
- ✓ Sanderson’s Scale
- ✓ Allred-Rochow’s Scale

PAULING'S SCALE

This scale is based on an empirical relation between the energy of a bond and the electronegativities of bonded atoms.

MULLIKEN'S SCALE

According to this scale, electronegativity could be regarded as the average of the ionization energy and electron affinity of an atom.

ELECTROPOSITIVITY

- ✓ It is the tendency of an atom to lose the most loosely bound electron.
- ✓ It is directly related to the metallic character of elements.
- ✓ It depends on atomic size and nuclear charge.
- ✓ As the atomic radius increases, electropositivity increases.

Along a period, electropositivity decreases from left to right.

Down the group, electropositivity increases.

Francium is the most electropositive element.

Fluorine is the least electropositive element.

VALENCY

- It is the combining capacity of an element.
- Or, it is the number of electrons lost or gained by an atom during a chemical reaction.
- Along a period, valency first increases upto the middle and then decreases (for s and p block elements only).

- ✓ **In a group, valency remains constant.**
- ✓ **Transition elements can show variable valency.**
- ✓ **Valency is numerically equal to oxidation number of the element.**
- ✓ **The difference is that oxidation number has a positive or negative sign but the valency doesn’t.**

PERIODIC TRENDS
ON
IONISATION ENERGY,
ELECTRON AFFINITY AND
ELECTRONEGATIVITY

ACROSS A PERIOD

The Ionisation energy, Electron Affinity and Electronegativity increases from left to right along a period. This is because

i) The decrease in atomic size of the elements along a period.

ii) The increase in nuclear charge on moving along a period.

iii) Decrease in shielding effect.

WITHIN A GROUP

The ionisation Energy, Electron Affinity and Electronegativity decreases down the group.

This is because along a group

i) The size of the atom increases.

ii) The nuclear charge decreases.

iii) Increase in shielding effect.

ATOMIC RADIUS

1. COVALENT RADIUS

- ✓ It is one half of the distance between the centres of the nuclei of two bonded atoms of the same element.
- ✓ Eg: The inter nuclear distance between the covalently bonded Hydrogen atoms is 74 pm.
- ✓ The covalent radius of Hydrogen is 37 pm.

2. VANDER WAALS RADIUS

It is one half of the distance between the centres of the nuclei of two non bonded atoms of the adjacent molecules of the element in the solid state.

3. METALLIC RADIUS

It is half the inter-nuclear distance separating the metal atoms in the metallic crystal.

Eg: The distance between two adjacent copper atoms in solid copper is 256 pm.

The metallic radius of copper is 128pm.

4. IONIC RADIUS

The effective distance from the centre of the nucleus of an ion up to which it has an influence on the electron cloud.

ISO ELECTRONIC SPECIES

Atoms and ions containing same number of electrons.

Eg: Na^{+} is isoelectronic with F^{-} .

O^{2-} is isoelectronic with Mg^{2+} .

NO_3^{-} is isoelectronic with CO_3^{2-} .

- **1. A cation is smaller than its parent atom but an anion is larger than its parent atom. Give reason.**
- **A cation is smaller than its parent atom.**
- **It has fewer electrons while its nuclear charge remains**
- **the same.**
- **An anion is larger than the corresponding parent atom**
- **The addition of one or more electrons would result in increased repulsion among the electrons and decrease**
- **in effective nuclear charge.**

- **2. The electron affinity of chlorine is higher than that of fluorine. Why?**
- Fluorine atom is much smaller than chlorine atom.
- Due to this, there is much crowding of electrons in small space around the fluorine nucleus.
- Due to this crowding, fluorine atom has less attraction for the outside electron in comparison to chlorine in which the crowding of electrons is less due to the bigger size of chlorine atom.
- As a result of this, electron affinity of fluorine is less than that of chlorine.

✓ **3. The Ionisation Energy of Nitrogen is greater than that of Oxygen. Why?**

✓ The electronic configuration of Nitrogen is $1s^2$, $2s^2$, $2p^3$

✓ The electronic configuration of Oxygen is $1s^2$, $2s^2$, $2p^4$.

✓ In the case of Nitrogen atom, the p orbitals are half filled.

✓ Atoms with half-filled electronic configurations have extra stability.

✓ Therefore, the ionization energy of Nitrogen is greater than that of Oxygen.

Thank You