PART-A: QUANTUM NUMBER

SOME IMPORTANT TERMS

Isotope: Atoms of given element which have same atomic number but different mass number are called isotope : e.g. ₁H¹ , ₁H² , ₁H³ etc.

Isobar: Atoms of different elements with the same mass number but different atomic number. e.g. ${}_{18}Ar^{40}$, ${}_{19}K^{40}$ and ${}_{20}Ca^{40}$

Iso-steres: Species having same number of electrons & same number of atoms. eg. N₂O, CO₂ *Iso-diaphers*: Species having same difference in number of neutrons and protons. eg. ¹² C, ¹⁶ O, and ${}^{14}_{7}N$.

Iso-electronic species: Species (atom, molecules or ions) having same number of electrons are called iso-electronic e.g H⁻, He, Li⁺ and Be²⁺ have 2 valence electrons each.

Note: Now a days this concept is extended to consider the same valence shell electron also.

Orbital: An orbital is defined as that zone in space where electron is most likely to be found . The orbitals are characterized by a set of 3 quantum numbers (n,l,m).

Nodal Plane:

Plane at which the probability of finding electron becomes zero.

Orbital Nodal plane eg. yz plane p_{x}

> xz plane p_{v}

xy plane

QUANTUM NUMBERS: Quantum numbers give complete information about an electron or orbital in an atom.

- 1. Principal Quantum number (n):
- Permissible value of $n \rightarrow 1$ to ∞ (i)

Designation of shell

- (ii) It represents shell number/energy level
- (iii) The energy states corresponding to different principal quantum numbers are denoted by letters K,L,M, N etc.

1 2 3 4 5 6 n L K M N O P

It indicates the distance of an electron from the nucleus.

- It also determines the energy of the electron. In general higher the value of 'n', higher is the energy (v) of a electron.
- (vi) It give an idea of total number of orbitals & electron (which may) present in a shell & that equal to n² & 2n² respectively.

(iv)

2. Azimuthal Quantum number (l):

- (i) The values of l depends upon the value of 'n' and possible values are '0' to (n-1).
- (ii) It gives the name of subshells associated with the energy level and number of subshells within an energy level.
- (iii) The different value of 'l' indicates the shape of orbitals and designated as follows:

Value	Notation	Name	Shape
l = 0	S	Sharp	Spherical
l=1	p	Principal	Dumbell
l=2	d	Diffused	Double Dumbell
l=3	f	Fundamental	Complex

(iv) It also determines the energy of orbital along with n.

For a particular energy level/shell energy of subshell is in the following order \rightarrow s < p < d < f

- (v) It gives the total number of orbitals in a subshell & that equals to (2l + 1) and number of electron in a subshell = 2(2l + 1)
- 3. Magnetic Quantum number (m or m_s):
- (i) The value of m depends upon the value of l and it may have integral value -l to +l including zero.
- (ii) It gives the number of orbitals in a given subshell and orientation of different orbitals in space. e.g. for n = 4, l = 0 to 3.

l	0	1	2	3
m	0	+1, 0, -1	+2, 1, 0, -1, -2	+3, +2, +1, 0, -1, -2, -3
Possible Orientation	1	3	5	7
Orbitals	S	p_x , p_y , p_z	$d_{z^2}, d_{x^2-y^2}$ d_{xy}, d_{yz}, d_{xz}	Not in syllabus

- (iii) The orbitals having same value of n and *l* but different value of m, have same energy in absence of external electric & magnetic field. These orbitals having same energy of a particular subshell is known as Degenerate orbitals.
- 4. Spin Quantum number (s) & magnetic spin quantum number (m_s):
- (i) While moving around the nucleus, the electron always spins about its own axis either clockwise or anticlockwise. The spin quantum number represents the direction of electron spin (rotation) around its own axis (clockwise or anticlockwise).
- (ii) There are two possible values of 'm_s' are $+\frac{1}{2}$ & $-\frac{1}{2}$ and represented by the two arrows \uparrow (spin up) and \downarrow (spin down).

RULES FOR FILLING ELECTRONS:

1. Pauli's exclusion principle

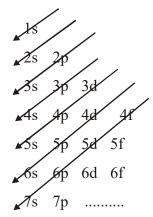
'No two electrons in an atom can have same values of all the four quantum numbers.

An orbital accommodates two electron with opposite spin. These two electrons have same values of principal, azimuthal and magnetic quantum number but the fourth, i.e. magnetic spin quantum number will be different. i.e.

For K, shell (n = 1)
$$l = 0$$
, m = 0
$$n = 1, l = 0, m = 0, m_s = +\frac{1}{2}$$
 For 2^{nd} Electron
$$n = 1, l = 0, m = 0, m_s = -\frac{1}{2}$$

2. Aufbau Principle (Means Building up):

The electrons are added progressively to the various orbitals in the order of increasing energies starting with the orbital of the lowest energy



1s < 2s < 2p < 3s < 3p < 4s < 3d < 4p < 5s < 4d < 5p < 6s < 4f < 5d < 6p < 7s < 5f < 6d < 7pAlternatively, the order of increase of energy of orbitals can be calculated from (n + l) rule.

- (i) Lower the value of (n + l) for an orbital, the lower will be its energy.
- (ii) If two orbitals have the same (n + l) value, then orbital with lower value of n has the lower energy.

e.g.
$$2p \& 3s$$

For $2p, n = 2, l = 1, (n + l) = 2 + 1 = 3$
For $3s, n = 3, l = 0, (n + l) = 3 + 0 = 3$

Then for 2p, n is lesser than for 3s, so 2p has lower energy than 3s.

(iii) $1s < 2s = 2p < 3s = 3p = 3d < 4s = 4p = 4d = 4f \dots$ energy order of different orbitals for single electron system like H, He⁺, Li⁺² etc.

Example.4 Write the increasing order of energies of 4s, 3p, 4p and 3d.

Ans. For 4s, n = 4, l = 0, (n + l) = 4For 3p, n = 3, l = 1, (n + l) = 4For 4p, n = 4, l = 1, (n + l) = 5For 3d, n = 3, l = 2, (n + l) = 5 $\Rightarrow 3p < 4s < 3d < 4p$ increasing order

3. Hund's rule of maximum multiplicity:

This rule deals with the filling of electrons into the orbitals belonging to the same subshell i.e. orbitals of equal energy, called degenerate orbitals.

"Electrons are distributed among the orbitals of a subshell in such a way as to give the maximum number of unpaired electron with parallel spins."

"Pairing of electrons in the orbitals belonging to the same subshell (p, d, f) does not take place until each orbital belonging to that subshell has got one electron each i.e. singly occupied. Moreover, the singly occupied orbitals must have the electrons with the parallel spin multiplicity"

Multiplicity = 2|S| + 1, where S = Total spin.

i.e.



Find total spin & multiplicity

Total spin S =
$$\frac{1}{2} + \frac{1}{2} + \frac{1}{2} = \frac{3}{2}$$

Multiplicity =
$$2 \times \frac{3}{2} + 1 = 4$$

i.e. 12 +1/2 +1/2

Total spin S =
$$\frac{1}{2} - \frac{1}{2} + \frac{1}{2} = \frac{1}{2}$$

Multiplicity =
$$2 \times \frac{1}{2} + 1 = 2$$

i.e.

Total spin S =
$$\frac{1}{2} + \frac{1}{2} + \frac{1}{2} = \frac{3}{2}$$

Multiplicity =
$$2 \times \frac{3}{2} + 1 = 4$$

i.e.

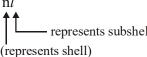
Total spin =
$$5 \times \frac{1}{2} = \frac{5}{2}$$

Multiplicity =
$$2 \times \frac{5}{2} + 1 = 6$$

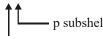
ELECTRONIC CONFIGURATION OF ATOMS:

The distribution of electrons in various shells, subshells and orbitals, in an atom of an element, is called its electronic configuration.

 $x \leftarrow no.$ of electrons in subshell nl



 $2p^5$ no. of electrons in p-subshell



Second shell

Electronic configuration:

Example.5 Nitrogen

Ans. ${}_{7}N: 1s^2, 2s^2 2p^3$ [Orbital notation method] $1s^2, 2s^2 2p_x^{-1} 2p_y^{-1} 2p_z^{-1}$ or ${}_{1s}$ ${}_{2s}$ ${}_{2p}$ [Orbital diagram method] or [He] $2s^2 2p^3$ [Condensed form]

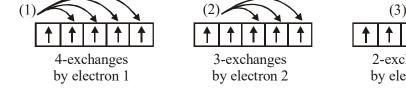
Extra stability of Half-filled and fully-filled orbitals.

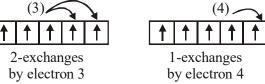
The electronic configuration of most of the atoms follows the Aufbau's rule. However, in certain elements such as Cr, Cu etc. Where the two subshells (4s and3d) differ slightly in their energies (4s < 3d), an electron shifts from a subshell of lower energy (4s) to a subshell of higher energy (3d), provided such a shift results in all orbitals of the subshell of higher energy getting either completely filled or half-filled.

$$_{24}$$
Cr \rightarrow [Ar] 3d⁵, 4s¹ and not [Ar] 3d⁴ 4s²
 $_{29}$ Cu \rightarrow [Ar] 3d¹⁰, 4s¹ and not [Ar] 3d⁹ 4s²

It has been found that there is extra stability associated with these electronic configuration. This stabilization is due to the following two factors.

- (i) Symmetrical distribution of electron: It is well known that symmetry leads to stability. The completely filled or half-filled subshell have symmetrical distribution of electron in them and are therefore more stable. This effect is more dominant in d and f-orbitals. This means three or six electrons in p-subshell, 5 or 10 electrons in d-dubshell and 7 or 14 subshell forms a stable arrangement.
- (ii) Exchange energy: This stabilizing effect arises whenever two or more electrons with the same spin are present in the degenerate orbitals of a subshell. these electrons tend to exchange their positions and the energy released due to this exchange is called exchange energy. The number of exchanges that can take place is maximum when the subshell is either half filled or fully filled. As result the exchange energy is maximum and so is the stability.

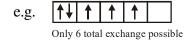




Total exchange pairs = 10

$$\frac{n(n-1)}{2} \rightarrow \text{Number of exchange pairs}$$

 $n \rightarrow$ Number of electron with parallel spins.



MAGNETIC PROPERTIES:

Paramagnetism:

- (i) The substances which are weakly attracted by magnetic field are paramagnetic and this phenomenon is known as paramagnetism.
- (ii) Their magnetic character is retained till they are in magnetic field and lose their magnetism when removed from magnetic field.

❖ Diamagnetism:

- (i) The substances which are weakly repelled by magnetic field are diamagnetic and this phenomenon is known as diamagnetism.
- (ii) Diamagnetic substances lack unpaired electrons and their spin magnetic moment is zero e.g., NaCl, N_2O_4 etc.

Spin magnetic moment :

The spin magnetic moment of electron (excluding orbit magnetic moment) is given by:

$$\mu = \sqrt{[n(n+2)]}$$
 B.M.

Where n is number of unpaired electron in species.

The magnetic moment is expressed in Bohr magneton (B.M.)

- **Example.6** A compound of vanadium has magnetic moment of 1.73 BM. Work out the electronic configuration of vanadium ion in the compound.
- Ans. Vanadium belongs to 3d series with Z = 23. The magnetic moment of 3d series metal is given by spin only formula.

$$\mu = \sqrt{n(n+2)}$$
 BM (BM = Bohr's magneton)

$$\because \qquad \sqrt{3} = 1.73$$

$$\Rightarrow$$
 $n(n+2) = 3 \Rightarrow n = 1$

- ⇒ Magnetic moment correspond to one unpaired electron.
- \Rightarrow Electronic configuration of vanadium atom 1s² 2s² 2p⁶ 3s² 3p⁶ 4s² 3d³.

For one unpaired electron 4 electron must be removed in which first 2 electron are lost from 4s orbital (outermost).

Electronic configuration of V⁺⁴

$$1s^2 2s^2 2p^6 3s^2 3p^6 4s^0 3d^1$$

PART-B: PERIODIC TABLE

INTRODUCTION:

The arrangement of all the known elements according to their properties in such a way that the elements of similar properties are grouped together in a tabular form is called periodic table.

Development of periodic table:

(A) LAVOISER CLASSIFICATION OF ELEMENTS

At first Lavoiser classified the elements into two categories.

(i) Metal

(ii) Non-metal

Note: This classification cannot categories the metalloid variety.

(B) DOBEREINER TRIAD RULE [1817]

- (i) He made groups of three elements having similar chemical properties called TRIAD.
- (ii) In Dobereiner triad, atomic weight of middle element is equal to the average atomic weight of first and third element.

e.g.

Cl Br I

35.5
$$80.0$$
 127 $\frac{35.5 + 127}{2} = 81.25$

Ca Sr Ba

40 87.5 137 $\frac{40 + 137}{2} = 88.5$

Li Na K

7 23 39 At. wt of Na = $\frac{7 + 39}{2} = 23$

(iii) Other examples – (K, Rb, Cs), (P, As, Sb), (S, Se, Te), (H, F, Cl), (Sc, Y, La)

(C) NEWLAND OCTAVE RULE [1865]

(i) He arranged the elements in the increasing order of their atomic mass and observe that properties of every 8th element was similar to the 1stone. like in the case of musical vowels notation.

(ii) At that time inert gases were not known.

(iii) The properties of Li are similar to 8th element i.e. Na, Be are similar to Mg and so on.

Drawback or Limitation:

- (a) This rule is valid only upto Ca. because after Ca due to presence of d-block element there is difference of 18 elements instead of 8 element.
- (b) After the discovery of inert gas this law had to be dropped out.
- (c) He failed in the case of heavier metals as Fe has been placed atoms with O and S.

E

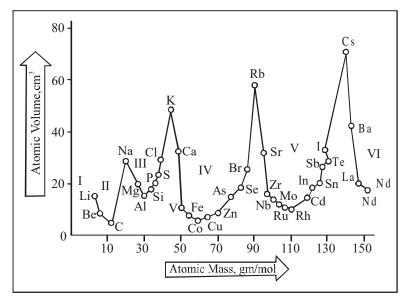
(D) LOTHER MEYER'S CURVE [1869]

- (i) He plotted a curve between atomic weight and atomic volume of different elements.
- (ii) The following observation can be made from the curve –
- (a) Most electropositive elements i.e. alkali metals (Li, Na, K, Rb, Cs etc.) occupy the peak positions on the curve.
- (b) Less electropositive i.e. alkali earth metal (Be, Mg, Ca, Sr, Ba) occupy the descending position on the curve.
- (c) Metalloids (B, Si, As, Te, At etc.) and transition metals occupy bottom part of the curve.
- (d) Most electronegative i.e. halogens (F, Cl, Br, I) occupy the ascending position on the curve.

Note: Elements having similar properties occupy similar position on the curve.

Conclusion:

On the basis of this curve Lother Meyer proposed that the physical properties of the elements are periodic function of their atomic weight and this become the base of Mendeleef's periodic table.



(E) MENDELEEV'S PERIODIC TABLE [1869]

- (i) *Mendeleev's periodic law* The physical and chemical properties of elements are the periodic function of their atomic weight
 - (ii) Characteristic of Mendeleev's periodic table -
 - (a) It is based on atomic weight
 - (b) 63 elements were known, noble gases were not discovered.
 - (c) He was the first scientist to classify the elements in a systamatic manner i.e. in horizontal rows and in vertical columns.
 - (d) Horizontal rows are called periods and there were 7 periods in Mendeleev's Periodic table.
 - (e) Vertical columns are called groups and there were 8 groups in Mendeleev's Periodic table.
 - (f) Each group upto VIIth is divided into A & B subgroups.'A' sub groups element are called normal elements and 'B' sub groups elements are called transition elements.
 - (g) The VIIIth group was consists of 9 elements in three rows.
 - (h) The elements belonging to same group exhibit similar properties.

- (iii) Merits or advantages of Mendeleev's periodic table -
- (a) Study of elements First time all known elements were classified in groups according to their similar properties. So study of the properties of elements become easier.
- (b) Prediction of new elements It gave encouragement to the discovery of new elements as some gaps were left in it.

Sc (Scandium), Ga (Gallium), Ge (Germanium), Tc (Technetium)

were the elements for whom position and properties were well defined by Mendeleev even before their discoveries and he left the blank spaces for them in his table.

e.g. - Blank space at atomic weight 72 in silicon group was called Eka silicon (means properties like silicon) and element discovered later was named Germanium.

Similarly other elements discovered after mendeleev periodic tabel were.

Eka aluminium – Gallium(Ga)

Eka Boron – Scandium (Sc)

Eka Silicon – Germanium (Ge)

Eka Manganese – Technetium (Tc)

(c) Correction of doubtful atomic weights—Correction were done in atomic weight of some elements.

Initially, it was found that equivalent weight of Be is 4.5 and it is trivalent (V = 3), so the weight of Be was 13.5 and there is no space in Mendeleev's table for this element. So, after correction, it was found that Be is actually divalent (V = 2). So, the weight of Be became $2 \times 4.5 = 9$ and there was a space between Li and B for this element in Mendeleev's table.

Corrections were done in atomic weight of elements are – U, Be, In, Au, Pt.

- (iv) Demerits of Mendeleev's periodic table -
- (a) Position of hydrogen Hydrogen resembles both, the alkali metals (IA) and the halogens (VIIA) in properties so Mendeleev could not decide where to place it.
- (b) Position of isotopes As atomic weight of isotopes differs, they should have placed in different position in Mendeleev's periodic table. But there were no such places for isotopes in Mendeleev's table.
- (c) Anomalous pairs of elements There were some pair of elements which did not follow the increasing order of atomic wts.

eg: Ar and Co were placed before K and Ni respectively in the periodic table, but having higher atomic weights.

$$\begin{pmatrix} Ar & K \\ 39.9 & 39.1 \end{pmatrix}$$
 $\begin{pmatrix} Te & I \\ 127.5 & 127 \end{pmatrix}$

$$\begin{pmatrix} \text{Co} & \text{Ni} \\ 58.9 & 58.6 \end{pmatrix}$$
 $\begin{pmatrix} \text{Th} & \text{Pa} \\ 232 & 231 \end{pmatrix}$

(d) Like elements were placed in different groups.

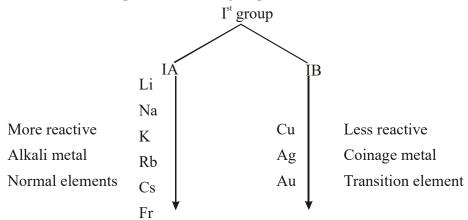
There were some elements like Platinum (Pt) and Gold (Au) which have similar properties but were placed in different groups in Mendeleev's table.

Pt	Au
VIII	IB

E

10 JEE-Chemistry ALLEN

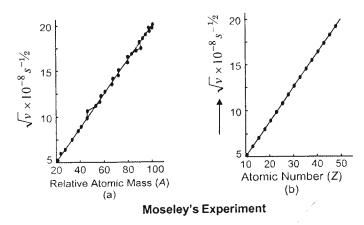
(e) Unlike elements were placed in same group.



Cu, Ag and Au placed in Ist group along with Na, K etc. While they differ in their properties (Only similar in having ns¹ electronic configuration)

(F) MODERN PERIODIC TABLE (MODIFIED MENDELEEV PERIODIC TABLE)

- (i) It was proposed by Moseley (1913).
- (ii) Modern periodic table is based on atomic number.
- (iii) Moseley did an experiment in which he bombarded high speed electron on different metal surfaces and obtained X-rays.



He found out that $\sqrt{v} \propto Z$ (where v = frequency) of X-rays from this experiment, Moseley concluded that the physical and chemical properties of the elements are periodic function of their atomic number. It means that when the elements are arranged in the increasing order of their atomic number, elements having similar properties gets repeated after a regular interval. This is also known as 'Modern Periodic Law'.

- (iv) Modern periodic law The physical & chemical properties of elements are a periodic function of their atomic number.
- (v) Characteristics of modern periodic table -
 - (a) 9 vertical columns called groups.
 - (b) IA to VIIA, IB to VIIB, VIII and 0
 - (c) Inert gases were introduced in periodic table by Ramsay.
 - (d) 7 horizontal series called periods.

(G)LONG FORM / PRESENT FORM OF MODERN PERIODIC TABLE

(It is also called as 'Bohr-Burry & Rang, Werner Periodic Table.)

- (i) It is based on the Bohr-Burry electronic configuration concept and atomic number.
- (ii) This model is proposed by Rang & Werner
- (iii) It consist of 7 horizontal periods and 18 vertical columns (groups)
- (iv) According to I. U. P. A. C. 18 vertical columns are named as 1st to 18th group.
- (v) The co-relation between the groups in long form of periodic table and in modern form of periodic table are given below.
- IA, IIA, IIIB, IVB, VB, VIB, VIIB, VIII, IB, IIIA, IVA, VA, VIA, VIIA, 0
- 1 2 3 4 5 6 7 8, 9, 10 11 12 13 14 15 16 17 18
- (vi) Elements belonging to same group having same no. of electrons in the outermost shell so their properties are similar.

Description of periods:

Period	n	Sub shell	No. of elements	Element	Name of Period
1.	1	1s	2	$_{1}H{2}He$	Shortest
2.	2	2s, 2p	8	$_{3}$ Li $_{10}$ Ne	Short
3.	3	3s, 3p	8	$_{11}Na{18}Ar$	Short
4.	4	4s, 3d, 4p	18	$_{19}$ K ${36}$ Kr	Long
5.	5	5s, 4d, 5p	18	$_{37}Rb{58}Xe$	Long
6.	6	6s, 4f, 5d, 6p	32	$_{55}$ Cs $ _{86}$ Rn	Longest
7.	7	7s, 5f, 6d, 7p	32	$_{87}$ Fr ${118}$ Og	Longest

CLASSIFICATION OF ELEMENTS INTO s, p, d & f BLOCK ELEMENTS:

s - block:

- (i) configuration ns $^{1-2}$
- (ii) last e enters in s orbital
- (iii) two groups IA or 1; IIA or 2

p-block:

- (i) configuration $ns^2 np^{1-6}$
- (ii) last e enters in p orbital
- (iii) six groups IIIA, IVA, VA, VIA, VIIA, zero or 13, 14, 15, 16, 17, 18

d - block: [Transition Elements]

- (i) configuration $(n-1)d^{1-10}$ ns 0-2 (ii) last e enters in d orbital
- (iii) their two outermost shell are incomplete
- (iv) 10 groups IIIB, IVB, VB, VIB, VIIB, VIII(Triad), IB, IIB or 3, 4, 5, 6, 7, (8, 9, 10), 11, 12
- (v) four series 3d, 4d, 5d, 6d belong to 4th, 5th, 6th & 7th period respectively in long form of Periodic table.

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f - block : [Inner Transition]

- (i) configuration $(n-2)f^{0-14}(n-1)d^{0-2}ns^2$
- (ii) last e enters in f orbital
- (iii) two series 4f Lanthanides & 5f Actinides belong to 6th & 7th period respectively in long form of Periodic table.

Neil's Bohr's classification of elements:

Using electronic configuration as the criteria, elements are of four types. The classification of the elements into these groups is dependent on the extent to which the s, p, d and f orbitals are filled.

Inert Gases:

- (a) s and p-orbitals of the outer most shell of these elements are completely filled. The outermost electronic configuration is ns^2np^6 .
- (b) Helium is also inert gas but its electronic configuration is 1s²

Representative or Normal Elements:

- (a) Outermost shell of these elements is incomplete. The number of electrons in the outermost shell is less than eight.
- (b) s-and p-block elements except inert gases are called normal or representative elements.

Transition Elements:

- (a) These metals were placed between s-block metals and p-block elements so, are named transition metals.
- (b) Their outermost electronic configuration is similar to d-block elements i.e. $(n-1) d^{1-10} ns^{1-2}$.
- (c) Last two shells of these elements namely outermost and penultimate shells are incomplete.
- (d) The last shell contains one or two electrons and the penultimate shell may contain more than eight and up to eighteen electrons.
- (e) According to definition of transition elements, those elements which have partly filled d-orbitals in neutral state or in any stable oxidation state are called transition elements. According to this definition Zn, Cd and Hg (IIB group) are d-block elements but not transition elements because these elements have d¹⁰ configuration in neutral as well as in stable +2 oxidation state.

Inner Transition Elements:

- (a) In these elements last three shells i.e. last, penultimate and prepenultimate shells are incomplete.
- (b) These are related to IIIB i.e. group 3.
- (c) The last shell contains two electrons. Penultimate shell may contain eight or nine electrons and pre-penultimate shell contains more than 18, up to 32 electrons.
- (d) Their outemost electronic configuration is similar to f-block element

i.e.
$$(n-2)f^{0-14}(n-1)d^{0-2}ns^2$$

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METALS, NON-METALS & METALLOIDS

Despite of classifying elements into s, p, d and f-blocks another broad classification of elements based on their properties. The elements can be broadly classified into

(a) Metals:

Majority of the elements in periodic table are metals and appears on the left side of the periodic table.

Properties:

- (i) These are usually solid at room temperature [exception mercury]
- (ii) They have high melting and boiling point [exception **Gallium & Cesium** have very low melting point (303 K and 302 K respectively)]
- (iii) They are good conductor of heat and electricity.
- (iv) They are malleable (can be flattened into thin sheets by hammering) and ductile (can be drawn into wires)

(b) Non-Metals:

These are placed at the top right hand side of periodic table. As we move horizontally along a period, the property of elements changes from metallic (on left) to non-metallic (on the right).

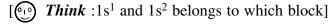
Properties:

- (i) These are usually solids or gases at room temperature.
- (ii) They have low melting point and boiling point (exception: **Boron, Carbon**).
- (iii) Most Non-metallic solids are brittle and are neither malleable nor ductile.
- (c) Metalloids (Semi-metals):

Properties of these elements shows the characteristics of both metals and non-metals. Silicon (Si), Germanium(Ge), Arsenic(As), Antimony(Sb) and Tellurium(Te) are metalloids.

ESTIMATING POSITION OF AN ELEMENT FROM ITS ELECTRONIC CONFIGURATION

The last electron enters in which subshell gives idea of its block.



Period number = Principal quantum number of valence shell electron in ground state electronic configuration.

Group number for s block = number of valence shell electron

Group number for p block = 10 + number of valence shell electron

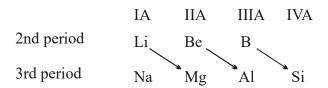
Group number for d block = number of [ns + (n-1) d] electron

Group number for f-block = 3

[Use these carefully while locating the position.]

SOME COMMONLY USED TERMS

- 1. *Noble Gases*: Element of group 18 are called noble gases. These are also called as inert gases because their outermost ns and np orbitals are completely filled (except He and 1s²) and these gases are non-reactive in nature under ordinary conditions.
- **2.** Typical elements: Elements of second and third period are known as typical elements.
- 3. *Diagonal relationship*: Properties of elements of second period resemble with the element of third period. These resemblance between properties of 2^{nd} & 3^{rd} period are called diagonal relationship.



4. Bridge elements:

The typical elements of third period are also called bridge elements as the division between two subgroups A and B starts from these elements. In second group Mg acts as a bridge element. The properties of bridge element are some what mixed properties of the elements of two subgroups as magnesium shows similarities with alkaline earth metals (IIA) on one hand and with zinc metals (IIB) on the other.

IUPAC NOMENCLATURE OF THE ELEMENT:

The names are derived by using roots for the three digits in the atomic number of the element and adding the ending –ium. The roots for the number are

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

Thus element with atomic number 109 will be named as **une** (**u** for 1, **n** for 0 and **e** for 9). Table summarises the names of the elements with atomic number above 100.

PART-C: PERIODIC PROPERTIES

PERIODICITY:

- (a) The regular gradation in properties from top to bottom in a group and from left to right in a period is called periodicity in properties.
- (b) In a period, the ultimate shell remain same, but the number of electron gradually increases.
- (c) In a group, the number of electron in the ultimate shell remains same, but the values of n increases.

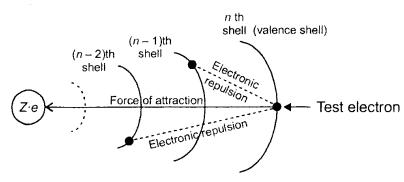
Cause of periodicity

- (a) The cause of periodicity in properties is due to the same outermost shell electronic configuration coming at regular intervals.
- (b) In the periodic table, elements with similar properties occur at intervals of 2, 8, 8, 18, 18 and 32. These numbers are called magic numbers.

SCREENING EFFECT (s) AND EFFECTIVE NUCLEAR CHARGE ($Z_{\rm eff}$)

- (a) Valence shell electron suffer force of attraction due to nucleus and force of repulsion due to inner shell electrons.
- (b) The decrease in force of attraction on valence electron due to inner shell electron is called screening effect or shielding effect. (i.e. total repulsive force is called shielding effect.)
- (c) Due to screening effect, valence shell electron experiences less force of attraction by nucleus.
- (d) Due to screening effect, net attractive force felt by the electron is measured by effective nuclear charge, $Z_{\rm eff}$
- (e) If nuclear charge = Z, then effective nuclear charge = $Z \sigma$ (Where σ 'sigma' is called screening constant/sheilding constant)

So,
$$Z_{eff} = Z - \sigma$$



<u>CALCULATION OF σ </u> (using slater's rule)

To calculate the shielding constant (σ):

(a) Write the electronic configuration of the element in the following order and groupings: (1s), (2s, 2p), (3s, 3p), (3d), (4s, 4p), (4d), (4f), (5s, 5p), etc.

For s and p electrons:

- (b) Electrons in any group to the right of the (ns, np) group contribute nothing to the shielding constant.
 - (n-shell no. of the electron for which σ is calculated)
- (c) All of the other electrons in the (ns, np) group, shield the concern electron to an extent of 0.35 each. (Except for the 1s orbital for which value is 0.30).
- (d) All electrons in the (n-1) shell shield to an extent of 0.85 each.
- (e) All electrons (n-2) or lower group shield completely; that is, their contribution is 1.00 each.

For d and f electrons:

- (f) Electrons in any group to the right of the nd or nf group contribute nothing to the shielding constant.
- (g) All the other electrons in the nd or nf group, shield the valence electron to an extent of 0.35 each.
- (h) All electrons in groups lying to the left of the nd or nf group contribute 1.00.

	(Effectiv	e Nucl	ear charge of ele	ments of second p	oeriod)	
Element	Electronic	Z	σ of ns & np	σ (n-1)	Total	Effective
	Configaration		electron	orbital	Screeing	nuclear
					Constant	charge#
			(a)	(b)	$(\mathbf{a} + \mathbf{b})$	$Z^*=Z-\sigma$
₃ Li	$1s^2 2s^1$	3	_	$0.85 \times 2 = 1.70$	1.70	1.30
₄ Be	$1s^2, 2s^2$	4	$1 \times 0.35 = 0.35$	$0.85 \times 2 = 1.70$	2.05	1.95
₅ B	$1s^2, 2s^2, 2p^1$	5	$2 \times 0.35 = 0.70$	$0.85 \times 2 = 1.70$	2.40	2.60
₆ C	$1s^2, 2s^2, 2p^1$	6	$3 \times 0.35 = 1.05$	$0.85 \times 2 = 1.70$	2.75	3.25
$_{7}N$	$1s^2, 2s^2, 2p^3$	7	$4 \times 0.35 = 1.40$	$0.85 \times 2 = 1.70$	3.10	3.90
O_8	$1s^2, 2s^2, 2p^4$	8	$5 \times 0.35 = 1.75$	$0.85 \times 2 = 1.70$	3.45	4.55
₉ F	$1s^2, 2s^2, 2p^5$	9	$6 \times 0.35 = 2.10$	$0.85 \times 2 = 1.70$	3.80	5.20

Calculated for valence electron.

Key Points:

- (a) From left to right in a period Z_{eff} increases
- (i) For s and p-block elements, Z_{eff} in a period increases by 0.65 where atomic number increases by 1, and hence atomic size decreases considerably.
- (ii) In transition series Z increase by + 1 but screening constant increases by 0.85 So Z_{eff} is increased by 0.15
 - (1 0.85 = 0.15) [Because e⁻ enters in (n 1) orbit which has value of $\sigma = 0.85$]
- (b) From top to bottom in a group Z_{eff} remain constant for s-block elements, after Li and Be.

Element	Li	Na	K	Rb	Cs	Fr
Z_{eff}	1.30	2.20	2.20	2.20	2.20	2.20

Example-7:

What is the effective nuclear charge at the periphery of nitrogen atom when an extra electron is added during the formation of an anion. Also find the value of $Z_{\rm eff}$ when the atom is ionized to N^+ .

Ans. Ground state electron configuration of $N(Z = 7) = 1s^2 2s^2 2p^3$

Electron configuration of $N^- = (1s^2) (2s^2 2p^4)$

Shielding constant for the last 2p electron,

$$\sigma = [(2 \times 0.85) + (5 \times 0.35)] = 3.45$$

So
$$Z_{eff} = Z - \sigma = 7 - 3.45 = 3.55$$

Electron configuration of $N^+ = (1s^2) (2s^2 2p^2)$

Shielding constant for the last 2p electron,

$$\sigma = [(2 \times 0.85) + (3 \times 0.35)] = 2.75$$

So Z_{eff} for last electron on $N^+ = 7 - 2.75 = 4.25$

ATOMIC RADIUS:

Problem in calculating actual size of atom and hence distance between nuclei is calculated giving rise to three type of radii for atoms.

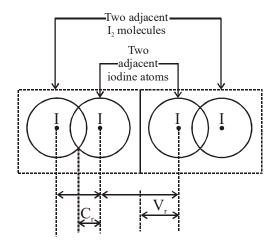
(a) Covalent radius:
$$C_r = \frac{d}{2}$$

[Used for H₂, Cl₂ and such molecules]

(b) Metallic Radius:
$$M_{\rm r} = \frac{d}{2}$$

[Used for metals]

(c) VanderWaal's Radius or Collision radius



VanderWaal's radius = $\frac{1}{2}$ × Internuclear distance between nuclei of two neighbouring atoms

belonging to nearest molecules.

VanderWaal's radius > Metallic radius > Covalent radius

The VanderWaal's radius and covalent radius of chlorine atom are 1.80 Å and 0.99 Å respectively *Ionic Radius*

A neutral atom changes to a cation by the loss of one or more electrons and to an anion by the gain of one or more electrons. The magnitude of charge on cation and anion is equal to the number of electrons lost or gained respectively. The ionic radii of the ions present in an ionic crystal may be calculated from the internuclear distance between the two ions.

(a) Radius of Cation

Radius of cation is smaller than that of corresponding atom. Since due to removal of electron(s), Z_{eff} increases.

(b) Radius of an Anion

Radius of an anion is invariably larger than that of the corresponding atom, since due to addition of electron(s) $Z_{\rm eff}$ decreases.

E

Factors affecting atomic radius:

(a) Z_{eff} increases, atomic radius decreases

- Li > Be > B > C > N > O > F
- (b) Number of shell(n) increases, atomic radius increases
- Li < Na < K < Rb < Cs
- (c) Screening effect increases, atomic radius increases.
- (d) Magnitude of –ve charge increases, atomic radius increases $O < O^- < O^{-2}$
- (e) Magnitude of +ve charge increases, atomic radius decreases $Mn > Mn^{+2} > Mn^{+3} > Mn^{+4}$
- (f) Bond order increases, atomic radius decreases

$$N-N > -N = N - N = N$$

Periodic Trend:

- (a) For normal elements:
 - (i) Across a period: It decreases from left to right in a period as Z_{eff} increases.

(ii) In a group: It increases from top to bottom in a group as number of shells increases.

Ex.
$$Li < Na < K < Rb < Cs$$

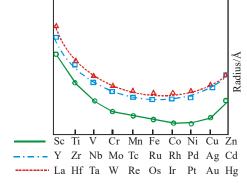
- Note: In III A group size of Al and Ga is nearly same or Ga slightly smaller than Al (transition contraction)
 - (b) For inert gases:

In respective period generally, the atomic radius of inert gas is largest, because for inert gas VanderWaal's radius is defined. The VanderWaal's radius of inert gases also increases on moving from top to bottom in the group.

(c) For transition elements:

From left to right in a period:

Element	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
Atomic radius (Å)	1.44	1.32	1.22	1.17	1.17	1.17	1.16	1.15	1.17	1.25



Trends in atomic radii of transition elements

In a group:

- (i) The atomic radius of elements increases on moving down the first transition series (3d) to second transition series (4d). This is due to the increases in number of shells with the increase in atomic number.
- (ii) The atomic radii of second (4d) and third (5d) transition series in a group is almost same except Y(39) and La(57)
- (d) For inner transition elements:

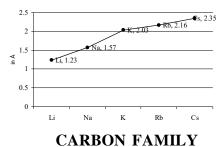
As we move along the lanthanide series, there is a decrease in atomic as well as ionic radius. The decrease in size is regular in ions but not so regular in atoms. This is called lanthanide contraction*.

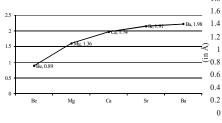
Exceptions:

- (1) Noble gases have largest atomic sizes as compared to corresponding halogen [Vanderwaal radii]. However, their covalent radii are smaller e.g. Xe.
- (2) Size of Ga and Al are same, or Ga slightly smaller than Al [Z_{eff} increasing]
- (3) Size of Hf & Zr are same (lanthanide contraction)

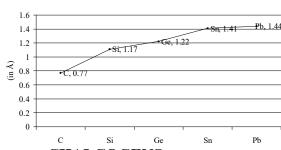
ALKALI METALS ALKALINE EARTH METALS

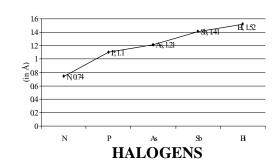
BORON FAMILY





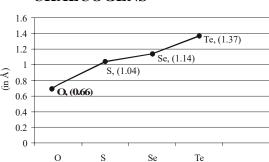
NITROGEN FAMILY (PNICOGENS)

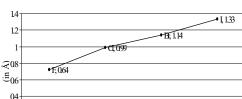




B, 0.8







what can you predict or say about the increment in size along a group and decrement along a period]

ISOELECTRONIC MONOATOMIC SPECIES [Size α 1/Z]:

- (i) S^{2-} , Cl^{-} , K^{+} , Ca^{2+} , Sc^{3+}
- (ii) H⁻, He, Li⁺
- $\mbox{(iii)} \qquad O^{-2} \ , \ F^- \ , \ Na^+ \ , \ Mg^{+2}, \ Al^{+3} \label{eq:continuous}$
- (iv) $\frac{\text{radius of cation}}{\text{radius of anion}} = \frac{Z_{\text{eff}} \text{ of Anion}}{Z_{\text{eff}} \text{ of Cation}}$

IONISATION ENERGY:

Amount of energy required to remove the most loosely bounded electron from an isolated gaseous atom form its ground state electronic configuration.

Units: kJ mol⁻¹, k cal mol⁻¹, eV per atom.

Ionisation is endothermic (endoergic) i.e. requires energy. Hence $\Delta H_{ionsation}$ is +ve.

$$M + Energy (IE_1) \longrightarrow M^+ + e^-$$

$$\mathbf{M} \longrightarrow \mathbf{M}^{+} + \mathbf{e}^{-} \qquad \Delta \mathbf{H} = \mathrm{IE}_{1}$$

$$\begin{array}{ll} M^+ \longrightarrow M^{+2} + e^- & \Delta H = IE_2 \\ M^{+2} \longrightarrow M^{+3} + e^- & \Delta H = IE_3 \end{array} \bigg] Successive \ ionisation \ energy$$

 $IE_3 > IE_2 > IE_1$ (always)

20

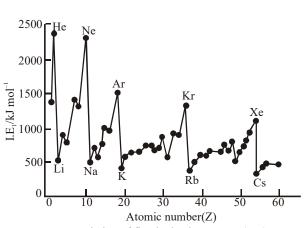
FACTORS AFFECTING IONISATION ENERGY:

- (1) Atomic size: Varies inversely
- (2) Screening effect: varies inversely
- (3) Nuclear charge (Z): varies directly
- (4) Special electronic configuration of outermost electron (half filled / fully filled)
- (5) Type of orbital involved in Ionisation: s > p > d > f.

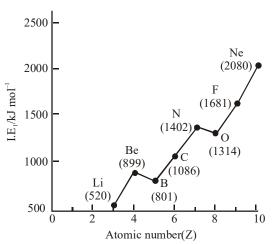
Note: Half fillness and full fillness of inner orbitals, affects d block and f block trends.

General Trend : Along period I.E. increases [with some exception] $[Z_{eff} \uparrow]$

Along a group I.E. decrease $[Z_{eff}$ constant, $n \uparrow]$



Variation of first ionization energy (I.E₁) with atomic number for elements with Z = 1 to 60



First ionization energy (I.E₁) of elements of the second period as a funciton of atomic number(Z)

Exception:

- (1) Along a period, half filled and fully filled configurations have higher I.E. e.g. Be > B and N > O.
- (2) along a group, Ga > Al

PROPERTIES AFFECTED BY IONISATION ENERGY:

- (1) Metallic character
- (2) Reducing power
- (3) Tendency to stay in which state A^{+1} . A^{+2} or A^{+3}

Note:

- (a) Helium (He) has the highest ionisation energy (IE₁) among all the elements and Caesium (Cs) has the least (IE₁) value.
- (b) Ionisation potential of inert gases is very high due to most stable s^2p^6 electronic configuration.

Element He $IE_1(eV)$ 24.5

Ne 21.6

Ar 15.8 Kr 14.0 Xe 12.1 Rn 10.7

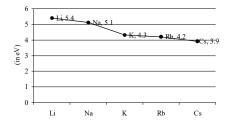
(c) For isoelectronic species I.P. increases with positive charge and decreases with negative charge. e.g. $Al^{+3} > Mg^{+2} > Na^+ > F^- > O^{-2} > N^{-3}$

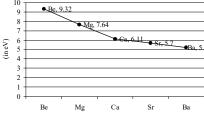
ALLEN

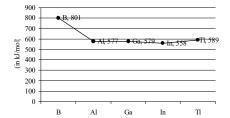
Graphical representation of ionisation energy:

ALKALI METALS

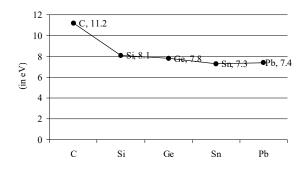
ALKALINE EARTH METALS GROUP III A



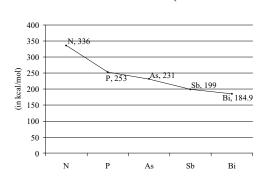




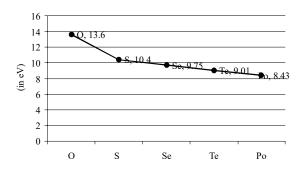
CARBON FAMILY



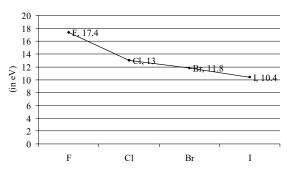
NITROGEN FAMILY (PNICOGENS)











Ionisation energy of d-block elements:

 1^{st} , 2^{nd} , 3^{rd} IE's are increasing from left to right for 1^{st} Transition series, but not regularly.

For 2^{nd} IE Cr > Fe > Mn and Cu > Zn

For 3^{rd} IE Mn > Cr > Fe and Zn has highest.

Element		Sc	Ti	v	Cr	Mn	Fe	Co	Ni	Cu	Zn
Atomic number	uati au	21	22	23	24	25	26	27	28	29	30
Electronic configur	M	$3d^{\scriptscriptstyle 1}4s^{\scriptscriptstyle 2}$	$3d^24s^2$	$3d^34s^2$	$3d^{5}4s^{1}$	$3d^{5}4s^{2}$	$3d^{6}4s^{2}$	$3d^74s^2$	$3d^{10}4s^2$	$3d^{10}4s^{1}$	$3d^{10}4s^2$
	$M^{^{2+}}$	$3d^1$	$3d^2$	$3d^3$	$3d^4$	$3d^5$	$3d^6$	$3d^7$	$3d^8$	$3d^{9}$	$3d^{10}$
	$M^{^{3+}}$	[Ar]	$3d^{1}$	$3d^2$	$3d^3$	$3d^4$	$3d^5$	$3d^6$	$3d^7$	_	_
Enthalpy of atomis	sation,	$\Delta_{a}H^{\odot}/kJ \text{ mol}^{-1}$									
Ionisation Enthalp	y, ,	326 ∆₁H [©] /kJ mol ⁻¹	473	515	397	281	416	425	430	339	126
$\Delta_{_{l}}H^{\circ}$	I	631	656	650	653	717	762	758	736	745	906
	II	1235	1309	1414	1592	1509	1561	1644	1752	1958	1734
	III	2393	2657	2833	2990	3260	2962	3243	3402	3556	3829

ELECTRON AFFINITY & ELECTRON GAIN ENTHALPY (EGE):

Electron Affinity: Amount of energy released when an electron is added to an isolated gaseous atom. $Units: k \ J \ mol^{-1}$, $k \ Cal \ mol^{-1}$ and eV per atom.

Addition of electron results in release of energy in most of the cases but for addition of second electron is always energy required. The sum of EA_1 & EA_2 is +ve (energy required)

E A
$$\alpha \frac{1}{\text{atomic size}} \alpha Z_{\text{eff}}$$
 (Cl has the highest E.A.)

Electron gain Enthalpy (EGE): When expressed in terms of enthalpy change (ΔH_{eg}) then it is termed as EGE Remember that $\Delta H = -$ ve for exothermic change.

For EA₁, energy is released
$$\therefore \Delta H_{eg1} = -ve$$
 (Not always)

For EA₂, EA₃energy is required
$$\therefore \Delta H_{eg2} = + \text{ ve (always)}$$

In general EA₁ + EA₂, energy is required.
$$\therefore (\Delta H_{eg1} + \Delta H_{eg2}) > 0$$

FACTORS AFFECTING ELECTRON AFFINITY:

- (1) **Atomic size:** varies inversely
- (2) *Nuclear change*: varies directly
- (3) For stable electronic configuration i.e. half filled and fully filled shells EA decreases.

General Trend: Along a period, electron affinity increases [with exception] as $Z_{eff} \uparrow$.

Along a group, electron affinity decreases after 3rd period. Between 2nd and 3rd period in p block electron affinity of 2nd period is lesser due to high electron density.

Exception:

- (1) A fully filled and half filled configuration have low values of EA or even sometimes energy is required rather than getting released.
- (2) 2nd period has lower value than 3rd owing to repulsion between electrons.

Electron affinity of the main-group elements (in electron volts)

1							18
Н							He
+0.754	2	13	14	15	16	17	-0.5
Li	Be	В	C	N	0	F	Ne
+0.618	≤ 0	≤ +0.277	+1.263	-0.07	+1.461	+3.399	-1.2
Na	Mg	Al	Si	P	S	Cl	Ar
+0.548	≤ 0	+0.441	+1.385	+0.747	+2.077	+3.617	-1.0
K	Ca	Ga	Ge	As	Se	Br	Kr
+0.502	_	+0.03	+1.2	+0.81	+2.021	+3.365	-1.0
Rb	Sr	In	Sn	Sb	Te	I	Xe
+0.486	_	+0.3	+1.2	+1.07	+1.971	+3.059	-0.8

ELECTRO NEGATIVITY:

Property of an atom in a molecule

F has highest electronegativity in periodic table.

Decreasing order \rightarrow F > O > Cl = N > Br > S = C > I > H.

Pauling Scale:
$$X_A \sim X_B = 0.208 \sqrt{\Delta_{A-B}}$$

Δ in kcal/mol

$$X_{A} \sim X_{B} = 0.102 \sqrt{\Delta_{A-B}}$$

 Δ in kJ/mol

$$\Delta = E_{A-B} - (E_{A-A} \times E_{B-B})^{1/2}$$

Mulliken's Scale: $X_M = \frac{IP + EA}{2}$ (IP & EA are expressed in eV)

Mulliken's values of EN are about 2.8 times higher then values of Pauli's scales.

i.e.
$$X_P = \frac{X_M}{2.8}$$

Allred-Rochows:
$$X_{AR} = \frac{0.359Z_{eff}}{r^2}$$
; $X_P = X_{AR} + 0.744$

r = covalent radius of atom (in Å)

 Z_{eff} = Effective nuclear charge on periphery

FACTORS AFFECTING ELECTRO NEGATIVITY:

- (1) *Nuclear attraction*: varies directly
- (2) **Atomic radius:** varies inversely
- (3) *Charge on ions:* More positive charge more electronegativity and more –ve charge less electronegativity.
- (4) *Hybridisation*: to be discussed later in bonding.

General Trends: Along a period, electronegativity increases

Along a group, electronegativity decreases

Exceptions: None noteworthy.

Note: Electronegativity of F > Cl but Electron affinity of Cl > F

Electronegativity of Some Elements (on Paulling's Scale)

Н							
2.1		-					
Li	Ве	В	С	N	0	F	
1.0	1.5	2.0	2.5	3.0	3.5	4.0	
Na	M g	Αl	Si	P	S	Cl	
0.9	1.2	1.5	1.8	2.1	2.5	3.0	
K	Ca	Ga	Ge	As	Se	Br	
0.8	1.0	1.6	1.8	2.0	2.4	2.8	
Rb	Sr	In	Sn	Sb	Te	I	
0.8	1.0	1.7	1.8	1.9	2.1	2.5	
C s	Ва	T1	Pb	Вi	Po	Αt	
0.7	0.9	1.8	1.8	1.9	2.0	2.2	
Fr	Ra						
0.7	0.9						

In **Pauling's Scale**, elements having almost same electronegativity are-

$$C \simeq S \simeq I \simeq 2.5$$

 $N = C1 = 3.0$
 $P = H = 2.1$
 $Cs = Fr = 0.7$
 $Be = A1 = 1.5$

node06\B080-BA\Kota\UEE(Advanced)\Leader\Che\Sheet\General Chemistry\Eng\01 . Theary.p65

PROPERTIES DEPENDENT ON ELECTRO NEGATIVITY:

(1) % ionic character

(2) Strength of bond

(3) Bond Length

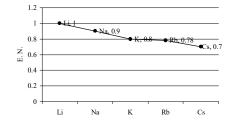
- (4) Nature of hydrides
- (5) Nature of hydroxide.

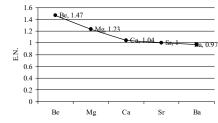
Graphical representation of Electronegativity:

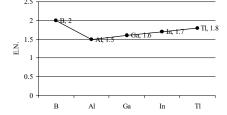
ALKALI METALS

ALKALINE EARTH METALS

BORON FAMILY

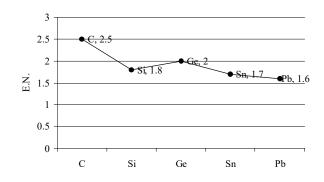


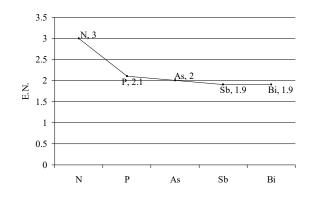




CARBON FAMILY

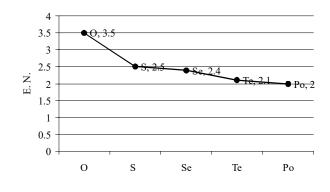
NITROGEN FAMILY (PNICOGENS)

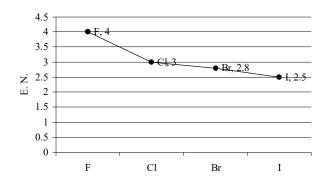




CHALCOGENS

HALOGENS





LATTICE ENERGY:

The amount of energy release during the formation of 1 mole crystal lattice from consituent gaseous ions.

$$Na^{+}(g) + Cl^{-}(g) \rightarrow NaCl(s)$$
 Lattice energy = -788 kJ mol⁻¹

OR

The lattice energy of an ionic compound is the energy required to separate 1 mole of solid ionic substance completely into gaseous ions.

$$NaCl(s) \rightarrow Na^{+}(g) + Cl^{-}(g)$$
 Lattice energy = +788 kJ mol⁻¹

Lattice energies are large and positive because of attraction between positive and negative ions. The potential energy of two interacting charged particles is given by:

$$E = K \frac{Q_1 Q_2}{r}$$

Where Q_1 and Q_2 are the charge on the particles in columb, and r is the distance between their centres in meters. The constant K has the value $9.0 \times 10^9 \text{ J} - \text{m/C}^2$.

Factors affecting lattice energy:

- (a) The lattice energy increases as the charge on the ions increases and as their radii decreases.
- (b) The magnitude of lattice energies however depends primarily on the ionic charges because ionic radii do not vary over a wide range.

For Example:

The lattice energy order for some compounds is given below.

Lil < LiBr < LiCl < LiF

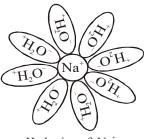
(Due to small size of halide ion F⁻ with small Li⁺)

HYDRATION ENERGY:

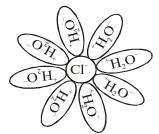
It is the energy released when 1 mol of gaseous ions are hydrated in water. It is directly proportional to nuclear charge and inversely proportional to size. It always decreases down the group.

(a) As the charge density of ion increases hydrated size (or aqueous radius) increases.

Size:
$$Li^{+}(aq) > Na^{+}(aq) > K^{+}(aq) > Rb^{+}(aq) > Cs^{+}(aq)$$



Hydration of Na



Hydration of Cl

(b) As the hydrated size of ion increases ionic mobility decreases, which decreases conductivity of ions.

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Mobility : $Li^{+}(aq) < Na^{+}(aq) < K^{+}(aq) < Rb^{+}(aq) < Cs^{+}(aq)$

Conductivity: $Li^{+}(aq) < Na^{+}(aq) < K^{+}(aq) < Rb^{+}(aq) < Cs^{+}(aq)$

(c) Hydration energy also affect the solubility of ionic compounds. If hydration energy is greater than lattice energy then ionic compound will be soluble in water. More is the hydration energy, solubility is more whereas if lattice energy decreases, solubility of ionic compound increases.

MISCELLANEOUS CHEMICAL PROPERTIES:

- 1. Periodicity of hydra acids:
 - (a) Acidic character of hydra acid increases from left to right in a period.
 - (b) Acidic character of hydra acid increases from top to bottom in a group.
- 2. Periodicity of oxy acids:
 - (a) Acidic character of oxy acid increases from left to right in a period.
 - (b) Acidic character of oxy acid decreases from top to bottom in a group.
- 3. Periodicity of nature of oxide:
 - (a) On moving from left to right in a period acidic nature of oxide generally increases.

e.g.
$$CO_2 < P_2O_5 < SO_3 < Cl_2O_7$$

- (b) On moving from top to bottom in a group acidic nature of oxide generally decreases.
- 4. General trends
 - (a) *Hydration energy* decreases along a group.
 - (b) Lattice energy decreases along a group.

:: Some points to Remember ::

(without considering radioactive elements)

- **1.** Second most electronegative elements is Oxygen
- 2. Hydrogen is the lightest element and Lithium is lightest metal.
- **3.** Helium has the highest value of I.P.
- **4.** In periodic table metalloids are only in p-block.
- 5. Total gaseous elements are 11 (He, Ne, Ar, Kr, Xe, Rn, H_2 , N_2 , O_2 , Cl_2 , F_2)
- **6.** Liquid metal at room temperature is Hg.
- 7. Diamond is hardest natural substance.
- **8.** Halogens have highest electron affinity and in that Cl has the highest amongst them.
- **9.** The largest cation of the periodic table = Cs^+ .
- 10. The smallest cation of the periodic table = H^+ .
- 11. The smallest anion of the periodic table = F^- .
- **12.** The biggest element of periodic table = Fr.
- 13. The smallest element of periodic table = H.
- **14.** Br is liquid non-metal element at room temperature.
- **15.** Osmium is the heaviest element known.
- **16.** Fluorine is the most electronegative element.

Helium 18 Argon 54 Xe 131.29 Xenon **Neon** Neon 36 **Kr** 83.80 Krypton 35 **Br** 79.904 Bromine 17 Carine 126.90 lodine p-Block Elements **VIA** (16) 8 0 15.999 Dxygen 16 S 32.066 Sulphur 83 **Bi** 208.98 Bismuth 15 P 30.974 hosporu Table 50 **Sn** 118.71 Tin the Periodic 13 **A** 26.982 Numinium **31 Ga** 69.723 Gallium 13) 5 10.811 Boron 204.38 Thallium **48 Cd** 112.41 Cadmium **80 Hg**200.59 Mercury **Cu** 63.546 Copper **78 Pt**195.08 Platinum **28** 58.693 Nickel Form of **45 T** 102.91 Rhodiur **58**.933 Cobolt 6 d-Block Elements **Extended or Long** 25 Mn 54.938 angane: 75 **Re** 186.21 Rhenium 107 **Bh** 270 Bohrium 183.84 Tungsten **VIB** 2 **2** 51.996 Non metals Metalloids **41 N D S** 92.906 Viobium **VB 105 Db**270 Dubnium **Metals** 178.49 Hafnium **4 40 Zr** 91.224 **164** 267 247 Lutherfordiu **57 La*** 138.91 anthanum 21 **Sc** 44.956 Scandium **33 ★** 88.906 Yttrium 9.0122 Beryllium 38 **Sr** 87.62 Strontium Mg 24.305 1agnesiun Be **20 Ca**40.078 Calcium **56 Ba**137.33 Barium **88 Ra**226 Radium 40 s-Block Elements 19 **K** 39.098 Potassium **87 Ff** 223 Francium 6.940 Lithium **Na** 22.990 Sodium 37 **Rb** 85.468 Rubidium **55 CS** 132.91 Cesium **₹**€ Period Group 2 IJ ဖ 3 4 /

		↓	0				<u>∓</u> 	-Block Ele	Elements						↑
		28	23	09	61	62	ೞ	2	65	99		88	69	20	71
9	*Lanthanide Series	ပီ	P	٥ Z	PB	Sm	Д	B9	9	2	£	Щ	E	Υp	Ľ
		140.12	140.91	144.24	145	150.36	151.96	157.25	158.93	162.50	164.93	167.26	168.93	173.07	174.97
		Cerinm	Praseodymium	Neodymium	Promethium	Samarium	Europium	Gadolinium	Terbium	Dyspro-	Holmium	Erbinm	Thulium	Ytterbium	Lutetium
		06	91	92	93	94	92	96	- 26	86	66	100	101	102	103
7	**Actinide Series	۲ ۲	Ра	-	Q Z	Pc	Am	E	ᄶ	ຽ	Es	E	ნ ∑	Ŷ	Ľ
		232.04	231.04	238.03	237	244	243	247	247	251	252	257	258	259	262
		Thorium	Protactinium	Uranium	Neptunium	Plutonium	Americium	Curium	Berkelium	Califonium	Einsteinium	Fermium	Mendelevium	Nobelium	Lawrencium

UPAC designations of groups of elements are given in brackets

QUANTUM NUMBER & PERIODIC TABLE

EXERCISE-I

Quantum number

1. Correct set of four quantum numbers for valence electron of rubidium (Z = 37) is

(A) 5, 0, 0, $+\frac{1}{2}$ (B) 5, 1, 0, $+\frac{1}{2}$ (C) 5, 1, 1, $+\frac{1}{2}$ (D) 6, 0, 0, $+\frac{1}{2}$

QN0020

2. The correct set of quantum numbers for the unpaired electron of chlorine atom is

n

m

(A) 2

1

0

(B) 2

(C) 3

(D) 3

0

QN0021

3. The total number of neutrons in dipositive zinc ions with mass number 70 is

(A) 34

(B) 40

(C)36

(D) 38

QN0001

4. Principal quantum number of an atom represents

(A) Size of the orbital

(B) Spin angular momentum

(C) Orbital angular momentum

(D) Space orientation of the orbital

ON0067

5. Which of the following sets of quantum numbers represent an impossible arrangement

n

m

m_c

(A) 3

2

-2

(B) 4

0

0

(C) 3

2

-3

1

(D) 5

3

0

QN0022

6. The explanation for the presence of three unpaired electrons in the nitrogen atom can be given by

(A) Pauli's exclusion principle

(B) Hund's rule

(C) Aufbau's principle

(D) Uncertainity principle

QN0012

The maximum number of electrons that can be accommodated in the Mth shell is 7.

(A) 2

(B) 8

(C) 18

(D) 32

QN0068

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E

8.	Which quantum num (A) Principal quantum	nber will determine the si	hape of the orbital (B) Azimuthal quantu	ım number	
	(C) Magnetic quantu	m number	(D) Spin quantum nu	mber	QN0005
9.	Which of the followi	ng has maximum numbe	er of unpaired electron (a	atomic number of	f Fe 26)
	(A) Fe	(B) Fe (II)	(C) Fe (III)	(D) Fe (IV)	QN0069
10.	A neutral atom of ar	n element has two K, ei	ght L, nine M and two I	N electrons then	electronic
	configuration of the	element is			QN0070
		Atomic & Id	onic Radii		
11.	The size of the follow (A) $Mg^{2+} < Na^+ < F^-$	ving species increases in	1 the order: (B) $F^- < Na^+ < Mg^{2+}$		
	(C) $Mg < F^- < Na^+$		(D) $Na^+ < F^- < Mg^{2+}$		PT0008
12.	Highest size will be	of	(2)110 11 11128		1 10000
	(A) Br ⁻	(B) I	(C) I ⁻	(D) I ⁺	PT0009
13.	Element Cu has two (A) $Cu^{+1} > Cu^{+2}$		Cu^{+2} . the right order of r (C) $Cu^{+1} = Cu^{+2}$	radii of these ion (D) $Cu^{+2} \ge C$	
					PT0010
14.	The correct order of $(A) N < F < Si < P$	increasing atomic size o	f element N,F, Si & P. (B) $F > N < P < Si$		
	(C) $F < N < P < Si$		(D) $F < N < Si < P$		PT0011
15.	The correct order of a (A) N < Li < B	atomic or ionic size	(B) Cl < Mg < Ca		
	(C) $Ca^{+2} < S^{-2} < Cl^{-1}$		(D) $Na^+ < Mg^{+2} < C$	1-	PT0012
		Ionization Energ	gy or Potential		
16.	In which of the follow		ration ionisation energy v	vill be maximum	in
		· ·	(C) [Ne] $3s^2 3p^3$		
					PT0015
17.		second ionisation potent			
	(A) C > N > O > F	(B) $O > N > F > C$	(C) O > F > N > C	(D) F > O > 1	N > C
			_		PT0016
18.	The ionization energ	y will be maximum for t	he process. $(C) C_{2} \rightarrow C_{2}^{+}$	(D) I; \ I;+	

PT0017

30	JEE-Chemistry				ALLEN
19.	The correct order of (A) Na < Mg > Al <		(B) Na > Mg < Al :	> Si	
	(C) Na > Mg > Al <	Si	(D) Na > Mg > Al :	> Si	PT0021
20.	Amongst the follows $(A) \text{ IE}_1 (Al) < \text{IE}_1 (Rl)$	ing, the incorrect statemed (Mg)	ent is (B) IE_1 (Na) $<$ IE_1 (Mg)	
	(C) $IE_2(Mg) > IE_2(Mg)$	(Na)	(D) IE_3 (Mg) $>$ IE_3	(Al)	PT0018
		Electron affinity or Ele	ectron Gain Enthalpy		
21.		s absorption of energy is			
	$(A) F \to F^-$	(B) $Cl \rightarrow Cl^-$	$(C) O^{-} \rightarrow O^{2-}$	(D) $H \rightarrow H$	_
					PT0022
22.	Of the following elec	ments, which possesses	the highest electron affi	nity?	
	(A) As	(B) O	(C) S	(D) Se	PT0023
23.	Electron affinities of (A) O < S < Cl < F	f O,F,S and Cl are in the	order. (B) O < S < F < Cl		
	(C) $S < O < Cl < F$		(D) $S < O < F < Cl$		PT0024
24.	Increasing order of E (a) 1s ² , 2s ² 2p ² (c) 1s ² , 2s ² 2p ⁶ 3s ² 3	Electron affinity for follo Sp^4	owing configuration. (b) 1s ² , 2s ² 2p ⁴ (d) 1s ² , 2s ² 2p ⁶ , 3s ²	$^23p^3$	
	(A) $d < a < b < c$	(B) $d < a < c < b$	(C) $a < b < c < d$	(D) a < b <	d < c
					PT0025
25.	Highest electron affi	nity is shown by			
	(A) F ⁻	(B) Cl ⁻	(C) Li ⁺	(D) Na+	PT0026
		Electron	-		
26.		ronic configuration of m	<u>e</u>		
	(A) $ns^2 np^3$	(B) $ns^2 np^4$	(C) $ns^2 np^5$	(D) $ns^2 np^6$	
					PT0028
27.		ch configuration of elen			
	$(A) 1_{0}^{2} 2_{0}^{2} 2_{0}^{2}$	(D) 1^{2} 2^{2} 2^{-6}	(C) 1.2 2.2 2.4	(D) 1^{2} 2^{2}	2-6 2-2 2-3

(A)
$$1s^2$$
, $2s^2 2p^3$

(B)
$$1s^2$$
, $2s^2 2p^6$

(C)
$$1s^2$$
, $2s^2 2p^4$

(D)
$$1s^2$$
, $2s^2 2p^6$, $3s^2 3p^3$

PT0129

28. On the Pauling's electronegativity scale, which element is next to F.

(A) Cl

(B) O

(C) Br

(D) Ne

PT0030

Bond distance C–F in (CF₄) & Si–F in (SiF₄) are respective 1.33Å & 1.54 Å. C–Si bond is 1.87 **29.** Å. Calculate the covalent radius of F atom ignoring the electronegativity differences.

(B)
$$\frac{1.33+1.54+1.8}{3}$$
 Å (C) 0.5 Å

(D)
$$\frac{1.54}{2}$$
Å

PT0130

30.	Wh	ich one is not co	orrect order of electron	egativity.		
	(A)	F > Cl > Br > I		(B) $Si > Al > Mg$	g > Na	
	(C)	Cl > S > P > Si		(D) None of thes	se	PT0031
31.			•	f $C - C$ bond length is are 2.0 and 3.0 respective		nd length is
	(A)	2.74 Å	(B) 1.37 Å	(C) 1.46 Å	(D) 1.28 Å	PT0131
			Misce	ellaneous		
32.	Cho	oose the s-block	element from the follo	owing:		
	(A)	$1s^2$, $2s^2$, $2p^6$, $3s^2$	s^2 , $3p^6$, $3d^5$, $4s^1$	(B) $1s^2$, $2s^2$, $2p^6$	$3s^2$, $3p^6$, $3d^{10}$, $4s^1$	
	(C)	$1s^2$, $2s^2$, $2p^6$, $3s^2$	s^2 , $3p^6$, $4s^1$	(D) all of the abo	ove	PT0036
33.	Fals	se statement for	periodic classification	of elements is		
	(A)	The properties	of the elements are per	iodic function of their a	tomic numbers.	
	(B)	No. of non-meta	allic elements is less th	an the no. of metallic el	lements.	
	(C)	First ionization	energy of elements do	es not increase regular	ly with the increasing	g of atomic
		number in a peri				
	(D)	d-subshell is fi	lled by final electron v	with increasing atomic	number of inner tra	nsition ele-
	n	ments.				PT0037
34.	Am	ong the following	ng which species is/are	paramagnetic		
	(i) S	Sr^{2+}	$(ii) Fe^{3+}$	(iii) Co ²⁺	(iv) S ²⁻	$(v) Pb^{2+}$
	(A)	i, iv, v	(B) i, ii, iii	(C) ii, iii	(D) iv, v	
						PT0035s
35.	If ea	ach orbital can	hold a maximum of th	ree electrons, the num	ber of elements in 9	th period of
	peri	odic table (long	form) are			
	(A)	48	(B) 162	(C) 50	(D) 75	PT0039
36.	Whic	ch of the followi	ng element has highest	metallic character.		
		Element	IP			
	(A)	P	17 eV			
	(B)	Q	2 eV			
	(C)	R	10 eV			
	(D)	S	13 eV			PT0040
37.		_		is $1s^2 2s^2 2p^6 3s^2 3p^4$. The above element in the		

(C) 34 & 16

(D) 34 & 8

PT0041

(B) 24 & 15

(A) 24 & 6

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More than one correct

- **38.** The number of d- electrons in Mn^{2+} is equal to that of
 - (A) p-electrons in N

(B) s-electron in Na

(C) d-electrons in Fe⁺³

(D) p-electrons in O⁻²

PT0042

- **39.** Which of the following is correct order of EA.
 - (A) N < C < O < F

(B) F > Cl > Br > I

(C) Cl > F > Br > I

(D) C < N < O < F

PT0051

- **40.** Select the correct statement(s).
 - (A) The value of electron gain enthalpy of an element can be -ve or +ve.
 - (B) In the periodic table, metallic character of the elements increases down the group and decreases across the period
 - (C) The Cl⁻ & S²⁻ are isoelectronic species but first one is not smaller in size than the second
 - (D) Ionization enthalpy of an atom is equal to electron affinity of cation

PT0059

- **41.** Which of the following are correct
 - (A) $IE_{2}(Mg) < IE_{2}(Na)$

- (B) EA(N) < EA(P)
- (C) Atomic size $Mg^{+2} > Atomic size (Li^+)$
- (D) IP of Na < Mg < Al

PT0054

- **42.** If Aufbau's principle and Hund's rule were not followed.
 - (A) K would have been d-block element & paramagnetic.
 - (B) Cu would have been s-block element.
 - (C) Cr would have been diamagnetic
 - In halogen, which of the following properties increase from iodine to fluroine
- (A) Ionisation energy

43.

(D) None of these

(B) Electronegativity

(C) Bond length

(D) Electron affinity

PT0060

PT0132

- **44.** In which of the following sets of elements 1st element is more metallic then second.
 - (A) Ba, Ca
- (B) Sb, Sn
- (C) Ge, S
- (D) Na, F

PT0061

- **45.** Amongst the following statements, which is / are correct?
 - (A) Electronegativity of sulphur is greater than that of oxygen.
 - (B) Electron affinity of oxygen is smaller than that of sulphur.
 - (C) Electron gain enthalpy of fluorine is most negative
 - (D) Electron gain enthalpy of chlorine is most negative

PT0055

- **46.** Select the correct statements (s)
 - (A) IE_1 of $F > IE_1$ of Cl

- (B) EA of O > EA of S
- (C) Ionic radius of Cl⁻ > Ionic radius of K⁺
- (D) None of these

QN0071

Assertion & Reason

47. Statement-1: The ground state configuration of Cr is [Ar] $3d^54s^1$

Statement-2: The energy of atom is lesser in 3d⁵ 4s¹ configuration compared to 3d⁴ 4s² configuration.

- (A) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.
- (B) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.
- (C) Statement-1 is true, statement-2 is false.
- (D) Statement-1 is false, statement-2 is true.

QN0072

48. Statement-1: The first ionization energy of Be is greater than that of B.

Statement-2: 2p orbital is lower in energy than 2s.

- (A) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.
- (B) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.
- (C) Statement-1 is true, statement-2 is false.
- (D) Statement-1 is false, statement-2 is true.

QN0073

49. Statement-1: IE_1 of N is greater than O.

Statement-2: N-atom is bigger than O in size.

- (A) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.
- (B) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.
- (C) Statement-1 is true, statement-2 is false.
- (D) Statement-1 is false, statement-2 is true.

QN0074

50. Statement-1 : First electron gain enthalpy is always -ve for an element.

Statement-2: Magnitude of electron gain enthalpy irregularly increases from left to right in a period.

- (A) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.
- (B) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.
- (C) Statement-1 is true, statement-2 is false.
- (D) Statement-1 is false, statement-2 is true.

QN0075

51. Statement-1: Ionization potential of Sn is less than Pb.

Statement-2: Ionization potential is inversally proportional to atomic size.

- (A) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.
- (B) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.
- (C) Statement-1 is true, statement-2 is false.
- (D) Statement-1 is false, statement-2 is true.

QN0076

52. Statement-1: Electron gain enthalpy of Cl is largest in periodic table.

Statement-2: Halogen's have largest electron gain enthalpy in a period.

- (A) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.
- (B) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.
- (C) Statement-1 is true, statement-2 is false.
- (D) Statement-1 is false, statement-2 is true.

QN0077

Paragraph for Question 53 to 55

The general electronic configuration of outer most and penultimate shell is given as $(n-1)s^2(n-1)p^6(n-1)d^xns^2$. Then for an element with n=4 and x=7.

- 53. The number of protons present in the divalent cation of the element of above configuration is :-
 - (A) 25
- (B) 26
- (C) 27
- (D) 28

QN0041

- **54.** The element is isoelectronic with which of the following species:-
 - (A) Fe⁻
- (B) Ni⁺
- (C) Cu²⁺
- (D) All of these

QN0041

- **55.** The number of unpaired electron in the trivalent cation of the given element in isolated gaseous state is:-
 - (A) 0
- (B) 3
- (C) 4
- (D) 1

QN0041

Match the column

56. If electrons are filled in the sub shells of an atom in the following order 1s, 2s, 2p, 3s, 3p, 3d, 4s, 4p, 4d, 4f...... then match the following element in List I with block in List II.

List-I

List-II

(A) K(19)

(P) s-Block

(B) Fe(26)

(Q) p-Block

(C) Ga(31)

(R) d-Block

(D) Sn(50)

(S) f-block

PT0133

57. Match the characteristics mentioned in List II with the process in List I.

List I

List II

(A) $O(g) + e^- \rightarrow O^-(g)$

(P) Positve electron gain enthalpy

(B) $O^{-}(g) + e^{-} \rightarrow O^{2-}(g)$

(Q) Negative electron gain enthalpy

(C) $Na^{-}(g) \rightarrow Na(g) + e^{-}$

(R) Exothermic

(D) $Mg^+(g) + e^- \rightarrow Mg(g)$

(S) Endothermic

ON0078

58. Match the column:

Column I

Column II

(A) Cl

(P) Metal

(B) F

(Q) Highest electron affinity

(C) Cu

(R) Highest Electronegative element

(D) He

- (S) Highest ionisation energy.
- QN0079

59. Match the column:

Column I

- Column II
- (A) Ni (P) Elements having number of unpaired electron in their dipositive = 2.
- (B) K (Q) At least 13 electrons are having magnetic quantum number 'zero'
- (C) Mn (R) Atom is paramagnetic
- (D) Pd (S) Element is not transition element

QN0080

Subjective:

60. Find total no. of orbitals in nickel which have $|m| \le 1$ and at least one electron is present, where 'm' is magnetic quantum number.

(Given your ans. as sum digits for example. If your ans is 57 then 5 + 7 = 12 and 1 + 2 = 3)

QN0033

Minimum number of electrons having $m_s = \left(-\frac{1}{2}\right)$ in Cr is "_____". **61.** QN0034

(1) 10, 10, 10

(3) 10, 11, 10

EXERCISE # J-MAIN

1.	The correct order of electron g	ain enthalpy with	negative sign of F, Cl, I	Br and I, havir	ng atomic number
	9, 17, 35 and 53 respectively	, is :-			[AIEEE-2011]
	(1) $I > Br > Cl > F$ (2) F	> Cl > Br > I	(3) Cl > F > Br > I	(4) Br $>$ 0	Cl > I > F
					PT0089
2.	The electrons identified by q	uantum numbers	ϵ n and ℓ :-		[AIEEE-2012]
			(c) $n = 3$, $\ell = 2$	(d) $n = 3$,	$\ell = 1$
	Can be placed in order of inc	creasing energy a	as		
	(1) (a) < (c) < (b) < (d)		(2) (c) < (d) < (b) <	(a)	
	(3) (d) < (b) < (c) < (a)		(4) (b) < (d) < (a) <	(c)	QN0050
3.	The increasing order of the i	onic radii of the	given isoelectronic spe	cies is :-	[AIEEE-2012]
	(1) K^+ , S^{2-} , Ca^{2+} , Cl^-		(2) Cl^- , Ca^{2+} , K^+ , S^2	2–	
	(3) S ²⁻ , Cl ⁻ , Ca ²⁺ , K ⁺		(4) Ca ²⁺ , K ⁺ , Cl ⁻ , S ²	2–	PT0090
4.	Which of the following param	nagnetic ions wou	ıld exhibit a magnetic n	noment (spin	only) of the order
	of 5 BM ?		[JE]	E-MAIN, (O	NLINE)-2012]
	(At. No : $Mn = 25$, $Cr = 24$	1, V = 23, Ti = 2	22)		
	$(1) V^{2+}$ $(2) T^{2}$	2+	$(3) \text{ Mn}^{2+}$	(4) Cr ²⁺	QN0051
5.	The following sets of quantu	m numbers repre	esent four electrons in a	an atom :-	
	(i) $n = 4$, $\ell = 1$ (ii) n	$=4, \ \ell = 0$	(iii) $n = 3, \ell = 2$	(iv) $n = 3$	$\ell = 1$
	The sequence representing in	ncreasing order o	of energy, is :- [JE	E-MAIN, (C	ONLINE)-2012]
	(1) (i) < (iii) < (ii) < (iv)		(2) $(ii) < (iv) < (i) <$	(iii)	
	(3) (iv) < (ii) < (iii) < (i)		(4) (iii) < (i) < (iv) <	(ii)	QN0083
6.	In which of the following arra	ingements, the sec	quence is not strictly ac	cording to the	e property written
	against it?		[JE	E-MAIN (O	n-Line)-2012]
	(1) CO2 < SiO2 < SnO2 < P	-			
	(2) $B < C < O < N$: increas	_	- -		
	(3) $NH_3 < PH_3 < AsH_3 < Sb$	H_3 : increasing l	oasic strength		
	(4) $HF < HCl < HBr < HI$:	increasing acid	strength		PT0134
7.	In an atom how many or	bital (s) will	have the quantum n	numbers; n	= 3, l = 2 and
	$m_l = +2$?		[JE]	E-MAIN, (O	NLINE)-2013]
	(1) 1 (2) 5		(3) 3	(4) 7	QN0052
8.	The numbers of protons, ele	ectrons and neutr	rons in a molecule of	heavy water	are respectively

(2) 8, 10, 11

(4) 11, 10, 10

E

9. Given [JEE-MAIN, (ONLINE)-2013]

(a) n=5, $m_i = +1$

(b)
$$n = 2$$
, $l = 1$, $m_l = -1$, $m_s = -1/2$

The maximum number of electron(s) in an atom that can have the quantum numbers as given in (a) and (b) are respectively:

- (1) 8 and 1
- (2) 25 and 1
- (3) 2 and 4
- (4) 4 and 1

QN0054

Which of the following represents the correct order of increasing first ionization enthalpy for Ca, Ba, **10.** S. Se and Ar? [JEE-MAIN-2013]

(1) Ca < S < Ba < Se < Ar

(2) S < Se < Ca < Ba < Ar

(3) Ba < Ca < Se < S < Ar

(4) Ca < Ba < S < Se < Ar

PT0091

The first ionisation potential of Na is 5.1 eV. The value of electron gain enthalpy of Na⁺ will be:-11. [JEE-MAIN-2013]

- (1) 2.55 eV
- (2) 5.1 eV
- (3) 10.2 eV
- (4) + 2.55 eVPT0092

12. Electron gain enthalpy with negative sign of fluorine is less than that of chlorine due to:

[JEE-MAIN 2013 (On-Line)]

- (1) Smaller size of chlorine atom
- (2) Bigger size of 2p orbital of fluorine
- (3) High ionization enthalpy of fluorine
- (4) Smaller size of fluorine atom

PT0093

13. Given

[JEE-MAIN 2013 (On-Line)]

Reaction

Energy Change (in kJ)

 $Li(s) \longrightarrow Li(g)$

161 520

 $Li(g) \longrightarrow Li^{+}(g)$

 $\frac{1}{2}F_2(g) \longrightarrow F(g)$

77

 $F(g) + e^{-} \longrightarrow F^{-}(g)$

(Electron gain enthalpy)

 $Li^{+}(g) + F^{-}(g) \longrightarrow LiF(s)$

-1047

$$Li(s) + \frac{1}{2}F_2(g) \longrightarrow Li F(s)$$

-617

Based on data provided, the value of electron gain enthalpy of fluorine would be:

- $(1) -300 \text{ kJ mol}^{-1}$
- $(2) -328 \text{ kJ mol}^{-1}$
- $(3) -350 \text{ kJ mol}^{-1}$
- $(4) -228 \text{ kJ mol}^{-1}$

PT0094

14. The order of increasing sizes of atomic radii among the elements O, S, Se and As is:

[JEE-MAIN 2013 (On-Line)]

- (1) As < S < O < Se (2) O < S < As < Se (3) Se < S < As < O (4) O < S < Se < As

PT0095

Which is the correct order of second ionization potential of C, N, O and F in the following? **15.**

- (1) O > F > N > C
- (2) O > N > F > C
- (3) C > N > O > F
- (4) F > O > N > C

JEE-MAIN 2013 (On-Line)]

PT0096

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[JEE(Main)-2014]

- (1) $5,1,1,+\frac{1}{2}$ (2) $5,0,1,+\frac{1}{2}$ (3) $5,0,0,+\frac{1}{2}$ (4) $5,1,0,+\frac{1}{2}$

QN0055

17. Which of the following series correctly represents relations between the elements from X to Y ? [JEE-MAIN 2014 (On-Line)]

$$X \longrightarrow Y$$

(1) ₁₈Ar \rightarrow ₅₄Xe

Noble character increases

(2) ₃Li \rightarrow ₁₉K

Ionization enthalpy increases

(3) ₆C \rightarrow ₃₂Ge

Atomic radii increases

 $(4) _{9}F \rightarrow _{35}Br$

Electron gain enthalpy with negative sign increases

PT0097

The ionic radii (in Å) of N³⁻, O²⁻ and F⁻ are respectively:-18.

[JEE-MAIN 2015]

- (1) 1.71, 1.40 and 1.36(2) 1.71, 1.36 and 1.40
- (3) 1.36, 1.40 and 1.71(4) 1.36, 1.71 and 1.40

PT0098

- **19.** In the long form of the periodic table, the valence shell electronic configuration of 5s² 5p⁴ corresponds to the element present in: [JEE-MAIN 2015 (On-Line)]
 - (1) Group 16 and period 5

(2) Group 17 and period 6

(3) Group 17 and period 5

(4) Group 16 and period 6

PT0099

Which of the following atoms has the highest first ionization energy? 20.

[JEE-MAIN 2016 (Off-Line)]

- (1) Sc
- (2) Rb
- (3) Na
- (4) K

PT0100

- 21. The non-metal that does not exhibit positive oxidation state is : [JEE-MAIN 2016 (On-Line)]
 - (1) Oxygen
- (2) Fluorine
- (3) Iodine
- (4) Chlorine

PT0101

22. The electronic configuration with the highest ionization enthalpy is:- [JEE-MAIN 2017]

- (1) [Ar] $3d^{10}4s^2 4p^3$
- (2) [Ne] $3s^2 3p^1$
- (3) [Ne] $3s^2 3p^2$
- (4) [Ne] $3s^2 3p^3$

PT0102

23. Consider the following ionization enthalpies of two elements 'A' and 'B':

Element	Ioniza	ation enth	alpy (kJ/mol)
	1 st	2 nd	3 rd
A	899	1757	14847
В	737	1450	7731

[JEE-MAIN 2017]

Which of the following statements is correct?

- (1) Both A and B belong to group-2 where A comes below B
- (2) Both A and B belong to group-1 where A comes below B
- (3) Both A and B belong to group-1 where B comes below A
- (4) Both A and B belong to group-2 where B comes below A

PT0103

24. In the following reactions, ZnO is respectively acting as a/an:

[JEE-MAIN 2017]

	(a) $ZnO + Na_2O \rightarrow Na_2ZnO_2$	(b) $ZnO + CO_2 \rightarrow ZnCO_3$
	(1) base and acid (2) base and base	e (3) acid and acid (4) acid and base
		PT00104
25.	The group having isoelectronic species is (1) O ²⁻ , F ⁻ , Na ⁺ , Mg ²⁺	S:- [JEE-MAIN 2017] (2) O^- , F^- , Na , Mg^+
	(3) O^{2-} , F^- , Na, Mg^{2+}	(4) O^{-} , F^{-} , Na^{+} , Mg^{2+} PT0105
26.	The correct order of electron affinity is :-	[JEE-MAIN 2018]
	(1) $Cl > F > O$ (2) $F > O > Cl$	(3) $F > Cl > O$ (4) $O > F > Cl$ PT0106
27.	For Na ⁺ , Mg ²⁺ , F ⁻ and O ²⁻ ; the correct of (1) Mg ²⁺ < Na ⁺ < F ⁻ < O ²⁻	order of increasing ionic radii is : [JEE-MAIN 2018] (2) $O^{2-} < F^- < Na^+ < Mg^{2+}$
	(3) $Na^+ < Mg^{2+} < F^- < O^{2-}$	(4) $Mg^{2+} < O^{2-} < Na^+ < F^-$ PT0107
28.	Which of the following arrangements slantiferromagnetic substance?	hows the schematic alignment of magnetic moments of [JEE-MAIN 2018]
	$(1) \bigoplus \bigoplus \bigoplus \bigoplus$	$(2) \bigoplus \bigoplus \bigoplus \bigoplus \bigoplus$
29.	(3) ① ① ① ① ① ① ① ① ① ① The quantum number of four electrons a	(4) (1) (1) (1) (2) (1) (QN0081) are given below - [JEE-MAIN ONLINE 2019]
4 7.		II. $n = 3$, $l = 2$, $m_l = 1$, $m_s = +\frac{1}{2}$
	III. $n = 4$, $l = 1$, $m_l = 0$, $m_s = +\frac{1}{2}$	IV. $n = 3$, $l = 1$, $m_l = 1$, $m_s = -\frac{1}{2}$
	The correct order of their increasing ener	
	(1) $IV < III < II < I$ (2) $IV < II < III <$	< I (3) I $<$ II $<$ III $<$ IV (4) I $<$ III $<$ IV
		QN0060
30.	The isoelectronic set of ions is : (1) N^{3-} , Li^+ , Mg^{2+} and O^{2-}	[JEE-MAIN ONLINE 2019] (2) Li ⁺ , Na ⁺ , O ²⁻ and F ⁻
	(3) F-, Li+, Na+ and Mg ²⁺	(4) N ³⁻ , O ²⁻ , F ⁻ and Na ⁺ QN0061
31.	The correct option with respect to the Part (1) Ga < Ge	uling electronegativity values of the elements is :- (2) Si < Al [JEE-MAIN ONLINE 2019]
	(3) $P > S$	(4) Te > Se $PT0109$
32.	The effect of lanthanoid contraction in the (1) decrease in both atomic and ionic rad (2) increase in atomic radii and decrease (3) increase in both atomic and ionic radii	in ionic radii
	(4) decrease in atomic radii and increase	in ionic radii PT0110

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33.	is:	gain enthalpy $(\Delta_{eg}H)$ of α		EE-MAIN ONLIN	
	(1) almost the same as	s that of the first			
	(2) negative, but less	negative than the first			
	(3) a positive value				
	(4) a more negative va	alue than the first			PT0111
34.	The correct order of hy	ydration enthalpies of alk	ali metal ions is - [J	JEE-MAIN ONLI	NE 2019]
	(1) $Li^+ > Na^+ > K^+ >$	$Rb^+ > Cs^+$	(2) $Li^+ > Na^+ > K^+ >$	$Cs^+ > Rb^+$	
	(3) $Na^+ > Li^+ > K^+ >$	$Rb^+ > Cs^+$	(4) $Na^+ > Li^+ > K^+ >$	$Cs^+ > Rb^+$	PT0112
35.	The IUPAC symbol for	or the element with atom	ic number 119 would be	e:	
				JEE-MAIN ONLI	NE 2019]
	(1) unh	(2) uun	(3) une	(4) uue	PT0113
36.	The element having g	reatest difference betwe	en its first and second i	onization energies,	is:
			[J	EE-MAIN ONLI	NE 2019]
	(1) Ca	(2) K	(3) Ba	(4) Sc	PT0114
37.	The correct statement	s among I to III regardin	ng group 13 element ox	ides are,	
	(I) Boron trioxide is a	cidic.	[J	EE-MAIN ONLI	NE 2019]
	(II) Oxides of alumini	um and gallium are amp	photeric.		
	(III) Oxides of indium	n and thallium are basic.			
	(1) (I), (II) and (III)	(2) (II) and (III) only	(3) (I) and (III) only	(4) (I) and (II) or	nly
					PT0115
38.	The pair that has similar	lar atomic radii is :	[JE]	E-MAIN ONLINI	E 2019]
	(1) Sc and Ni	(2) Ti and Hf	(3) Mo and W	(4) Mn and Re	PT0117
20			1	1.	
39.	The number of orbital	ls associated with quant			
			[J	EE-MAIN ONLI	NE 2020]
	(1) 11	(2) 25	(3) 15	(4) 50	QN0062
40.		sotopes (A), (B) and (C			

(3) 2

(2) 3

(1) 4

(4) 1

E

QN0063

41.	Within each pair of ele	ements of F & Cl, S &	Se, and Li & Na, respect	ively, the elemen	ts that release
	more energy upon an	electron gain are-	[JEE-MAIN	N ONLINE 2020)]
	(1) F, Se and Na		(2) F, S and Li		
	(3) Cl, S and Li		(4) Cl, Se and Na		PT0118
42.	The atomic radius of	Ag is closest to:	1	JEE-MAIN ON	ILINE 2020]
	(1) Cu	(2) Hg	(3) Au	(4) Ni	PT0119
43.	B has a smaller first is	onization enthalpy tha	an Be. Consider the follo	wing statements	:
	(I) It is easier to rem	ove 2p electron than 2	2s electron		
	(II) 2p electron of B is of Be.	more shielded from the	e nucleus by the inner core of	of electrons than the	ne 2s electrons
	(III) 2s electron has m	nore penetration power	er than 2p electron.		
	(IV) atomic radius of	B is more than Be			
	(Atomic number B =	= 5, Be = 4)			
	The correct statement	s are :]	JEE-MAIN ON	ILINE 2020]
	(1) (I), (II) and (III)		(2) (II), (III) and (IV)	
	(3) (I), (III) and (IV)		(4) (I), (II) and (IV)		PT0121

EXERCISE # J-ADVANCED

1. The electrons, identified by n & ℓ ;

[JEE 1999]

- (i) n = 4, $\ell = 1$
- (ii) n = 4, $\ell = 0$
- (iii) n = 3, $\ell = 2$
- (iv) n = 3, $\ell = 1$

can be placed in order of increasing energy, from the lowest to highest as:

- (A) (iv) < (ii) < (iii) < (i)
- (B) (iii) < (ii) < (iv) < (i)

(C)(i) < (iii) < (ii) < (iv)

(D) (iii) < (i) < (iv) < (ii)

QN0084

- **2.** Gaseous state electronic configuration of nitrogen atom can be represented as : [JEE 1999]
 - $(A) \uparrow \downarrow \uparrow \downarrow \uparrow \uparrow \uparrow \uparrow$

(B) $\uparrow\downarrow\uparrow\downarrow\uparrow$ \uparrow

(C) $\uparrow\downarrow\uparrow\uparrow\downarrow\uparrow$

(D) $\uparrow\downarrow$ $\uparrow\downarrow$ \downarrow \uparrow

QN0017

- 3. The electronic configuration of an element is 1s² 2s² 2p⁶ 3s² 3p⁶ 3d⁵ 4s¹. This represents its:

 [JEE 2000]
 - (A) excited state
- (B) ground state
- (C) cationic form
- (D) none

QN0082

4. **Statement-1**: F atom has a less negative electron gain enthalpy than Cl atom. [JEE 2000]

Statement-2: Additional electron is repelled more efficiently by 3p electron in Cl atom than by 2p electron in F atom.

- (A) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.
- (B) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.
- (C) Statement-1 is true, statement-2 is false.
- (D) Statement-1 is false, statement-2 is true.

PT0122

5. The correct order of radii is:

[JEE 2000]

- (A) N < Be < B
- (B) $F^- < O^{2-} < N^{3-}$
- (C) Na < Li < K
- (D) $Fe^{3+} < Fe^{2+} < Fe^{4+}$

PT0123

6. The IE_1 of Be is greater than that of B. [**T/F**]

[JEE 2001]

PT0124

7. The set representing correct order of IP_1 is

[JEE 2001]

- (A) K > Na > Li
- (B) Be > Mg > Ca
- (C) B > C > N
- (D) Fe > Si > C

PT0125

8. Identify the least stable ion amongst the following:

[JEE 2002]

- (A) Li
- (B) Be⁻
- (C) B⁻
- (D) C-
- PT0126

9. The maximum number of electrons that can have principal quantum number, n = 3, and spin quantum number, $m_s = -1/2$, is [JEE 2011]

QN0064

10. In an atom, the total number of electrons having quantum numbers n=4, $|m_{\ell}| = 1$ and $m_{s} = -\frac{1}{2}$ is:

[JEE Advanced 2014]

QN0065

11. The increasing order of atomic radii of the following group 13 elements is

(B)
$$Ga < Al < In < Tl$$

(C)
$$Al < In < Ga < Tl$$

(D)
$$Al < Ga < Tl < In$$

PT0127

12. The option(s) with only amphoteric oxides is (are):

[JEE 2017]

PT0128

ANSWER-KEY

EXERCISE # I

Que.	1	2	3	4	5	6	7	8	9	
Ans.	Α	С	В	Α	С	В	С	В	С	
Que.		1	0		11	12	13	14	15	16
Ans.	1s ²	2s² 2p ⁶ 3s	s ² 3p ⁶ 3d´	¹ 4s ²	Α	С	Α	С	В	С
Que.	17	18	19	20	21	22	23	24	25	26
Ans.	С	В	В	С	С	С	В	Α	С	С
Que.	27	28	29	30	31	32	33	34	35	36
Ans.	Α	В	С	D	D	С	D	С	D	В
Que.	37	38	39	40	41	42	43	44	45	46
Ans.	С	B, C	A, C	A, B, D	A, B	A, B, C	A, B	A, C, D	B, D	A, C
Que.	47	48	49	50	51	52	53	54	55	
Ans.	Α	С	В	D	В	В	С	D	С	
Que.			56					57		
Ans.	(A) →	R; (B) _	→ R; (C)	$\rightarrow Q$; (D)) → S	$(A) \rightarrow Q$	$R ; (B) \rightarrow$	P,S ; (C	\rightarrow S; (E	$Q(x) \rightarrow Q(x)$
Que.			58					59		
Ans.	(A) _	→ Q ; (B) -	→ R ; (C)	$\rightarrow P$; (D)	\rightarrow S	(A)→P,G	Q,R ; (B)_	→R,S ; (C))→Q,R ; ((D)→P,Q
Que.	60	61								
Ans.	4	9								

EXERCISE # J-MAIN

Que.	1	2	3	4	5	6	7	8	9	10
Ans.	3	3	4	3	3	3	1	1	1	3
Que.	11	12	13	14	15	16	17	18	19	20
Ans.	2	4	2	4	1	3	3	1	1	1
Que.	21	22	23	24	25	26	27	28	29	30
Ans.	2	4	4	4	1	1	1	4	2	4
Que.	31	32	33	34	35	36	37	38	39	40
Ans.	1	1	3	1	4	2	1	3	2	2
Que.	41	42	43					-	•	
Ans.	3	3	1							

EXERCISE # J-ADVANCED

Que.	1	2	3	4	5	6	7	8	9	10
Ans.	A	A	В	С	В	TRUE	В	В	9	6
Que.	11	12		•	•	-	-	•	•	-
Ans.	В	C, D								