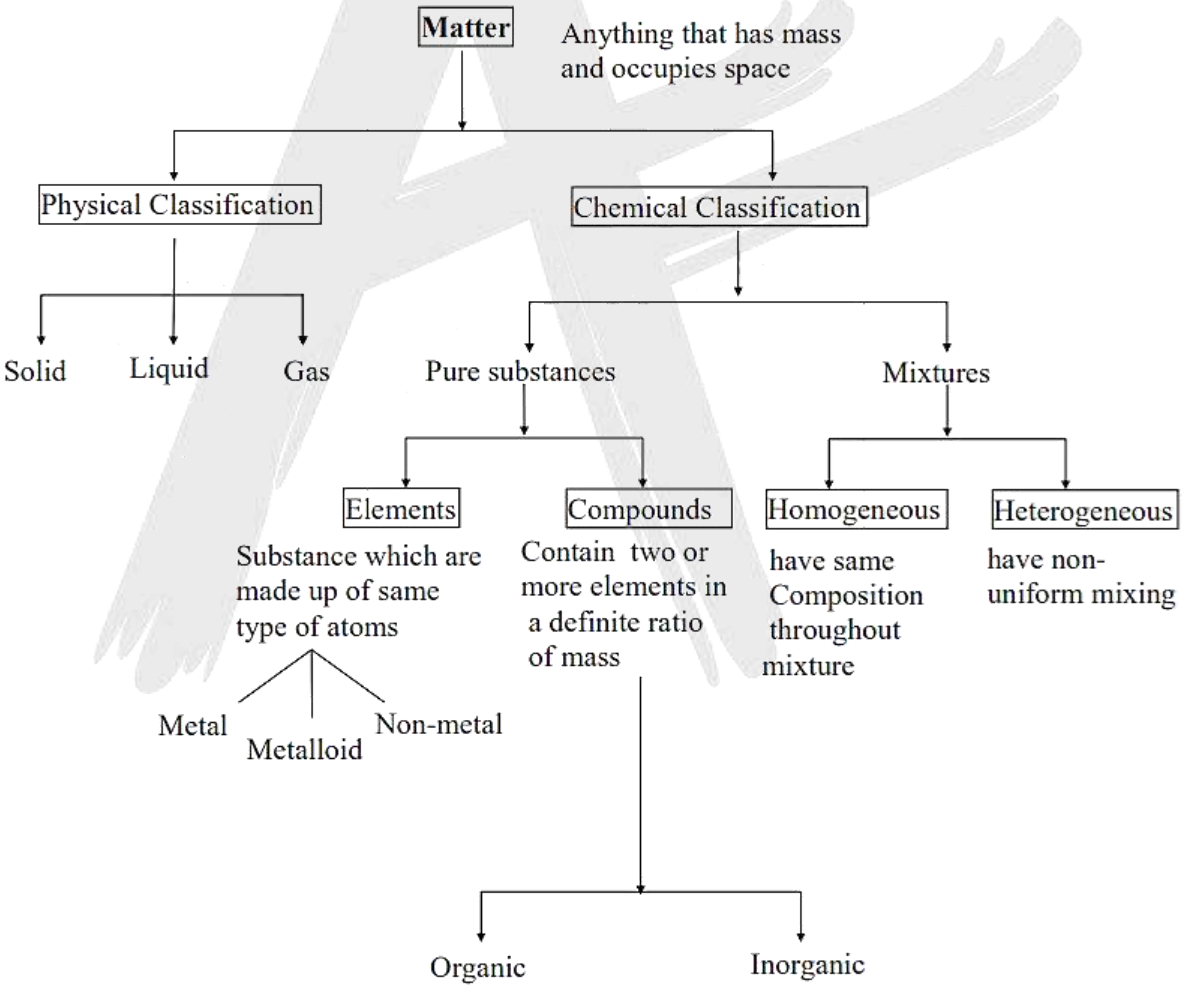
INTRODUCTION

➢ **Chemistry:**

It is a branch of physical science, which deals with the study of matters, its physical and chemical properties, chemical composition, physical and chemical changes, which it undergoes and the energy changes accompany these process.

➢ **Type of chemistry**

- **Organic chemistry** : Study of hydrocarbons and their derivatives.
- **Inorganic chemistry** : Study of all known elements and their compounds except hydrocarbons and their derivatives
- **Physical chemistry** : Study of laws governing by physical and chemical changes



- **Physical Substance:** Three types on the basis of physical state.

Property	Solid	Liquid	Gas
Particle distance	Minimum	Moderate	Maximum
Density	Maximum	Moderate	Minimum
Volume	Minimum	Moderate	Maximum
Shape	definite shape	no definite shape	no definite shape

- **Atomicity:** Number of atoms in a molecule.

Example: S_8 Se_8 Te_8 Po
N_2 O_2 H_2 X_2 [X → F, Cl, Br, I]
P_4 As_4 Sb_4 Bi

- **Examples of non-metal:**

Liquid - Bromine

Gas - N_2, O_2, H_2, Cl_2, F_2, all noble gas (He, Ne, Ar, Kr, Xe, Rn)

Solid - Phosphorus, Sulphur, Iodine

- **Examples of metal:**

Liquid metal —Hg

Solid - Iron, Sodium, Aluminium

Metalloid : Element which shows both metallic and non-metallic property

Example : Si, As, Sb, Ge, B, Te, Po

Compound : Made up of two or more than two different type of atom.

Example : H_2O oxidane NH_3 azane PH_3 phosphane
CH_4 methane BH_3 borane PbH_3 plumbane

Element : Substance made up of same atoms

Compound : Substance made up of two or more elements in a fixed ratio by mass.

Homogenous mixture : The mixture which has same composition throughout.

Hetrogenous mixture : The mixture which has different composition throughout.

Example :-

Matter		**Classification**
He	-	Pure → element → non-metal
Diamond	-	Pure → element → non-metal

Graphite - Pure → element → non-metal

Iron - Pure → element → metal

Air - mixture → homogenous

Alloy - mixture → homogenous (Note: All alloy are homogenous mixture)

Tap water - mixture → hetrogenous (Bacteria not distributed equally)

Cold drink before shaken - mixture → homogenous

Cold drink after shaken - mixture → heterogenous

Sand + water → mixture → heterogeneous

CCl_4 + water → mixture → heterogeneous

Alcohol + water → mixture → homogeneous

➢ **Atom :** An atom is the smallest unit of an element that may or may not have independent existence but takes part in a chemical reaction. They are made up of still smaller particles electron, proton and neutron.

Name of Particle	Mass	Nature of charge	Amount of charge	Presence in the atom
(i) Electron Symbol = (e) Notation = $_{-1}e^{o}$ Discoverer J.J.Thomson (1897)	9.11×10^{-28} g $\frac{1}{1837}$ th of H-atom	Negatively Charged	-1.602×10^{-19} Coulomb Or -4.8×10^{-10} e.s.u	Outside the nucleus
(ii) Proton Symbol = (p) Notation = ($_1H^1$) Discoverer Rutherford (1911)	1.6725×10^{-24} g	Negatively Charged	-1.602×10^{-19} Coulomb Or -4.8×10^{-10} e.s.u	Inside the nucleus of an atom
(iii) Neutron Symbol = (n) Notation = ($_0n^1$) Discoverer J. Chadwick (1932)	1.6725×10^{-24} g	Neutral	0	Inside the nucleus of an atom

- **Representation of atom :**

  ${}_{z}X^{A}$

  where,

  A → Mass number : (total number of protons + total number of neutrons present in an atom.)

  Z → Atomic number : (total number of protons present in an atom.)

  Example :- ${}_{20}Ca^{40}$

- **Isotope :** Atoms of given element which have same atomic number but different mass number are called isotope.

  Example:

  (a) ${}_{1}H^{1}$, ${}_{1}H^{2}$, ${}_{1}H^{3}$

  (b) ${}_{8}O^{16}$, ${}_{8}O^{18}$

  (c) ${}_{6}C^{12}$, ${}_{6}C^{14}$

  (d) ${}_{17}Cl^{35}$, ${}_{17}Cl^{37}$

- **Isobar :** Atoms of different elements with the same mass number but different atomic number.

  Example:

  (a) ${}_{18}Ar^{40}$ and ${}_{20}Ca^{40}$

  (b) ${}_{6}C^{14}$ and ${}_{7}N^{14}$

- **Iso-electronic species :** Species (atom, molecules or ions) having same number of electrons are called iso-electronic.

Example :

(a) C^{4-}, N^{3-}, O^{2-}, F^{-}, Ne, Na^{+}, Mg^{+2}, Al^{3+}

(b) Si^{4-}, P^{3-}, S^{2-}, Cl^{-}, Ar, K^{+}, Ca^{2+}, Sc^{3+}

(c) H_2S, HCl, Ar, SH^{-}

(d) NH_2^{-}, NH_3, CH_4, H_2O, OH^{-}, NH_4^{+}, NH^{2-}

(e) $[Ni(CO)_4]$, $[Co(CO)_4]^{-}$, $[Fe(CO)_4]^{2-}$, $[Fe(CO)_2(NO)_2]$

(f) CO_3^{2-}, NO_3^{-}, BO_3^{3-}

(g) SiO_4^{4}, PO_4^{3-}, SO_4^{2-}, ClO_4^{-}

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

- **Iso-sters :** Species having same number of electrons & same number of atoms.

Example:

(a) CH_4, NH_4^{+}

(b) CO_3^{2-}, NO_3^{-}, BO_3^{3-}

(c) NH_2^{-}, H_2O

(d) SiO_4^{4-}, PO_4^{3-}, SO_4^{2-}, ClO_4^{-}

- **Iso-diaphers :** Species having same difference in number of neutrons and protons.

Example :

(a) ${}_{15}P^{31}$, ${}_{17}Cl^{35}$, ${}_{11}Na^{23}$, ${}_{3}Li^{7}$, ${}_{13}Al^{27}$, ${}_{19}K^{39}$, ${}_{9}F^{19}$, all have isotopic excess of $(A - 2Z) = 1$.

(b) ${}_{6}C^{14}$, ${}_{8}O^{18}$, ${}_{1}T^{3}$, ${}_{24}Cr^{50}$, all have isotopic excess of $(A - 2Z) = 2$.

Isotones: Elements having the same number of neutrous are known as isotones.

Example:

(a) ${}_{12}Mg^{24}$ and ${}_{11}Na^{23}$ (b) ${}_{9}F^{19}$ and ${}_{8}O^{18}$

(c) ${}_{6}C^{14}$ and ${}_{8}O^{16}$ (d) ${}_{15}P^{31}$ and ${}_{16}S^{32}$

DO YOUR SELF – 1

1. Which of the following set(s) is/are isosters:

(A) N_2O, CO (B) N_2, CO_2 (C) $B_3N_3H_6, C_6H_6$ (D) HF, Ne

2. Which of the following is/are homogeneous mixture.

(A) Milk + water (B) Tap water (C) Milk (D) Oil + water

3. Which of the following set of species is isodiapher :

(A) ${}_{15}P^{31}$, ${}_{8}O^{18}$ (B) ${}_{6}C^{14}$, ${}_{8}O^{16}$ (C) ${}_{11}Na^{23}$, ${}_{13}Al^{27}$ (D) ${}_{24}Cr^{50}$, ${}_{19}K^{39}$

4. Which of the following is a heterogeneous mixture?

(A) Sugar solution (B) Petroleum (C) Air (D) Blood

5. Which of the following set contains only isoelectronic ions?

(A) $Zn^{+2}, Ca^{+2}, Ga^{+3}, A\ell^{+3}$ (B) $K^{+}, Ca^{+2}, Sc^{+3}, C\ell$

(C) $P^{-3}, S^{-2}, C\ell^{-}, Zn^{+2}$ (D) $Ti^{+4}, Ar, Cr^{+3}, V^{+5}$

➢ **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).

QUANTUM NUMBERS

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

General representation of an atom.

Atom → Shell → Subshell → Orbital → Electron

1. Principal Quantum number (n) :

(i) Permissible value of n → 1 to ∞

(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.

n	:	1	2	3	4	5	6
Designation of shell	:	K	L	M	N	O	P

(iv) It indicates the distance of an electron from the nucleus.

(v) It also determines the energy of the electron. In general higher the value of ' n ', higher is the energy.

(vi) It give an idea of total number of orbitals & electron (which may) present in a shell & that equal to n^2 & $2n^2$ respectively.

Energy : Value of n increases, energy level of shell increases but energy gap decreases.

$$n = 1 \quad 2 \quad 3 \quad 4 \quad 5 \ldots\ldots\infty$$

Order of Energy $= E_1 < E_2 < E_3 < E_4 < E_5 \ldots\ldots\infty$

$$E_2 - E_1 > E_3 - E_2 > E_4 - E_3 > E_5 - E_4 \ldots..$$

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.

(v) For a particular energy level/shell energy of subshell is in the following order : -

$\boxed{s < p < d < f}$

Closeness towards nucleus :

$\boxed{s > p > d > f.}$

(vi) It gives the total number of orbitals in a subshell & that equals to $(2l + 1)$ and number of electron in a subshell $= 2(2l + 1)$

Que. Which of the following relation is correct?

(A) $n > \ell$ (B) $n < \ell$ (C) $n = \ell$ (D) none of these

Ans. (A)

Que. Which of the following subshell do not exist?

(A) 4f (B) 5g (C) 3f (D) 2d

Ans. (C, D)

Que. If n = 6 then maximum possible value of ℓ is?

Ans. 5

Que. If $\ell = 7$ then minimum possible value of n is?

Ans. 8

3. Magnetic Quantum number (m) :

(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. The orbitals having same energy of a particular subshell is known as **Degenerate orbitals**.

Note: Multielectronic system: n and ℓ value must be same for degenerated orbitals.

➢ **Nodal Planes of different orbitals :**

Nodal plane is a plane at which the probability of finding an electron becomes zero.

Eg.

Orbital	**Nodal plane**	**Orbital**	**Nodal plane**
s	None	d_{xy}	XZ & YZ planes
P_x	YZ plane	d_{yz}	XZ & XY planes
P_y	XZ plane	d_{xz}	XY & YZ planes
P_z	XY plane	$d_{x^2} - {}_{y^2}$	Planes perpendicular to XY plane, passing through origin (nucleus) and inclined at 45° to X & axis.
		d_{z^2}	None (two nodal cones are available)

4. Spin Quantum number (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 ' s ' are $+\frac{1}{2}$ & $-\frac{1}{2}$ and represented by the two arrows : ↑ (spin up) and ↓ (spin down).

Practice Set:

1. If n = 4 then maximum value of ℓ is?

Ans. 3

2. If $\ell = 3$ then minimum possible value of n is

Ans. 4

3. If $\ell = 4$ then minimum possible value of n is?

Ans. 5

4. Which of the following value of ℓ is common for all shell?

Ans. 0

5. Which of the following mathematical value (minimum) is common for nℓm ?

Ans. 1

6. No. of degenerated orbitals in H^- if electron is present in 4^{th} excited state?

Ans. 3

7. Which of the following set of quantum number is correct.

	n	ℓ	m	s
(A)	2	2	1	$+\frac{1}{2}$
(B)	3	4	2	$+\frac{1}{2}$
(C)	4	3	4	$-\frac{1}{2}$
(D)	2	1	0	$-\frac{1}{2}$

Ans. (D)

DO YOUR SELF – 2

1. How many subshells are possible in P-shell :

(A) 3 (B) 6 (C) 7 (D) 1

2. For an electron magnetic quantum number $= -2$, the electron may be present in

(A) 3 d – orbital (B) 2p – orbital

(C) 4p - orbital (D) 5 s - orbital

3. Number of Valence shell electron in Fe is?

(A) 8 (B) 6 (C) 14 (D) 12

4. Hund's rule deals with the distribution of electrons in

(A) outer shell only (B) a subshell only

(C) an orbital (D) degenerate orbital

5. The number of possible orientation of d-orbitals in space is:

(A) 2 (B) 3 (C) 4 (D) 5

6. Maximum number of electrons in 3p - orbital?

(A) 2 (B) 10 (C) 6 (D) 3

7. In which pair both the orbitals have same shape, same orientation, but different energy?

(A) 3 d_{xy}, 4 d_{xy} (B) $5p_x$, $5p_y$ (C) $3p_x$, 3 d_{xy} (D) 4 s, $4p_x$

RULES FOR FILLING ELECTRONS

1. Pauli's exclusion principle :

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

(ii) 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. spin quantum number will be different. i.e.

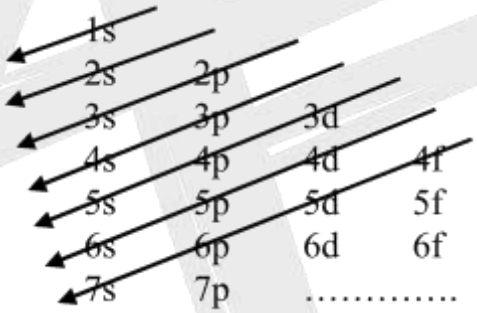
For He $= 1\ s^2$ K, shell $(n = 1), l = 0, m = 0$

For 1^{st} Electron $n = 1, l = 0, m = 0, s = +\frac{1}{2}$

For 2^{nd} Electron $n = 1, l = 0, m = 0, s = -\frac{1}{2}$

2. Aufbau Principle (Means Building up) :

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



Order of Energy :

$1\ s < 2\ s < 2p < 3\ s < 3p < 4\ s < 3\ d < 4p < 5\ s < 4\ d < 5p < 6\ s < 4f < 5\ d < 6p < 7\ s < 5f < 6\ d < 7p$

(ii) Alternatively, the order of increase of energy of orbitals can be calculated from $(n + l)$ rule.

(a) Lower the value of $(n + l)$ for an orbital, the lower will be its energy.

(b) If two orbitals have the same $(n + l)$ value, then orbital with lower value of n has the lower energy.

e.g. 2p&3 s
For $2p, n = 2, l = 1, (n + l) = 2 + 1 = 3$
For $3\ s, n = 3, l = 0, (n + l) = 3 + 0 = 3$

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

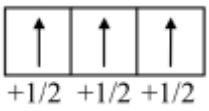
3. Hund's rule of maximum multiplicity :

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

(ii) "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."

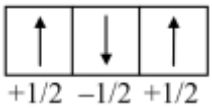
(iii) "Pairing of electrons in the orbitals belonging to the same subshell (p, d, f) does not take place until each orbital belonging to that subshell has got one electron each i.e. singly occupied. moreover, the singly occupied orbitals must have the electrons with the parallel spin multiplicity" More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

Find total spin & multiplicity

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. 

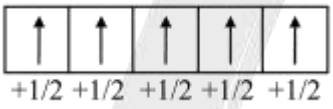
Total spin $S = \frac{1}{2} - \frac{1}{2} + \frac{1}{2} = \frac{1}{2}$

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 $S = 5 \times \frac{1}{2} = \frac{5}{2}$

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

i.e. $H = ls^1$

$He = ls^2$

$Li = ls^1 2s^1$

$Be = ls^2 2s^2$

$B = ls^2 2s^2 2p^1$

$C = ls^2 2s^2 2p^2$

Note : Requirement : Hund's rule valid from Carbon

Hund's rule is valid for Degenerate orbitals and it is not valid for s orbital.

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.

- **Representation :** nl^x

where,

n → shell number

l → represents subshell

x → number of electrons in subshell

For example :-

$2p^2$ → number of electron in p–subshell

p–subshell

Second shell

$_3$Li: $1s^2, 2s^1$ or $[He]2s^1$ or

1s	2s
↑↓	↑

- **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 (4 s < 3 d), 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.

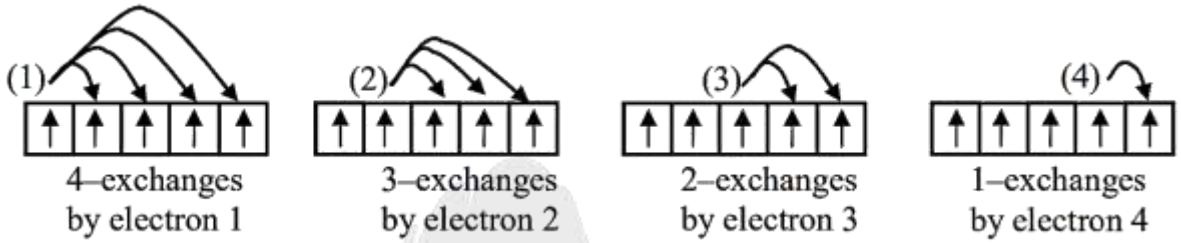
$_{24}$Cr → $[Ar]3\,d^5, 4\,s^1$ and not $[Ar]3\,d^4 4\,s^2$

$_{29}$Cu → $[Ar]3\,d^{10}, 4\,s^1$ and not $[Ar]3\,d^9 4\,s^2$

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-subshell and 7 or 14 in f-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 the stability increases.

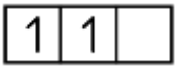
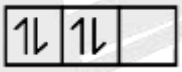
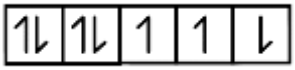


Total exchange pairs = 10

$\frac{n(n-1)}{2}$ → **Number of exchange pairs** n → Number of electron with parallel spins.

DO YOUR SELF – 3

1. Which of the following arrangement of electron is **CORRECT**:

(A)  (B)  (C)  (D) 

2. Which of the following order of energy level of orbital for Li^{+2} is correct?

(A) $1s < 2s < 2p < 3s < 3p$ (B) $1s < 2s = 2p < 3s = 3p$

(C) $1s > 2s > 2p > 3s > 3p$ (D) $1s = 2s = 2p = 3s = 3p$

3. Which set of three quantum numbers (n, l, m_l) corresponds to a 3 d orbital?

(A) 3, 3, 2 (B) 3, 2, 2 (C) 3,2,3 (D) 2,3,3

4. Which one of the following orbitals can hold two electron?

(A) 3 s (B) $2p_x$ (C) $4\ d_{xy}$ (D) All of these

5. Which one of the following represents an acceptable set of quantum numbers for an electron in an atom? (Arranged as n, l, m_l and m_s)

(A) $5,4,-5,1/2$ (B) $1,0,0,1/2$ (C) $2,2,-1,-1/2$ (D) $3,3,3,1/2$

6. Which of the following is not a valid set of four quantum numbers (n, l, m_l, m_s) ?

(A) $3,1,-1,-1/2$ (B) $2,0,0,+1/2$ (C) $2,1,2,+1/2$ (D) $2,1,0,-1/2$

7. The correct set of four quantum numbers for the valence electrons of sodium atom $(Z = 11)$ is :

(A) $3,0,1,+\frac{1}{2}$ (B) $3,0,0,+\frac{1}{2}$ (C) $4,0,0,+\frac{1}{2}$ (D) $2,1,0,+\frac{1}{2}$

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 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.)

Ex.: A compound of vanadium has magnetic moment of 1.73 BM. Find out the electronic configuration of vanadium ion in the compound.

Ans. Vanadium belongs to 3 d series with $Z = 23$. The magnetic moment of 3 d series metal is given by spin only formula.

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

$\because (1.73)^2 = n(n+2)$

$3 = n(n+2)$

$\Rightarrow$ $n = 1$

$\Rightarrow$ Magnetic moment correspond to one unpaired electron.

$\Rightarrow$ Electronic configuration of vanadium atom $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^3$.

For one unpaired electron 4 electron must be removed in which first 2 electron are lost from 4 s orbital (outermost). and the remaining electron remove from 3 d (inner shell).

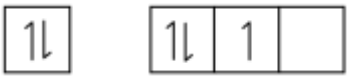
Electronic configuration of V^{+4}; $1s^2 2s^2 2p^6 3s^2 3p^6 4s^0 3d^1$

MISCELLANEOUS EXAMPLES

Que. Which of the following arrangement of electron is correct?

(A)  (B) 

(C)  (D) 

(E) 

Ans. **(D)**

Que. Number of electrons s, p, d, f orbital can accomodate?

Ans.

s	p	d	f
2	2	2	2

Que. Maximum number of electrons in s, p, d, f subshell?

Ans.

s	p	d	f
2	6	10	14

Que. Total number of nodal planes in orbitals of p subshell?

Ans. 3

Que. Each d orbital has two nodal plane?

Ans. False (d_{z^2} has nodal cone)

Que. Lobes of orbital which are present in nodal plane of P_z

Ans. $P_x, P_y, d_{xy}, d_{x^2-y^2}$

Que. If $\mu = 2\sqrt{2}$, then number of unpaired electron in Ti^{+x}, then define the value of x ?

Ans. 2 electron, $x = 2$

Que. The total number of electron in phosphorous for which $n + l = 2$?

Ans. 2

Que. The total number of electron in Cu for which $l - m = 1$?

Ans. Cu = $1s^2, 2s^2, 2p^6, 3s^2\ 3p^6\ \ 3d^{10}, 4s^1$

$\ell =$ 0 0 1 0 1 2 0

m = 0 0 −1 0 −1 −2 0

0 0 −1

1 +1 0

+1

+2

Que. If $\ell = 0$ to n + 1, then number of subshells, orbitals and electrons in 3^{rd} shell.

Ans. $\ell = 0$ to n + 1

K = 1 → 0,1,2 1s 1p 1d

L = 2 → 0,1,2,3 2s 2p 2d 2f

M = 3 → 0,1,2,3,4 3s 3p 3d 3f 3g

Subshells = 5

Orbirtals = 25

Electrons = 50

Que. Write the electronic configuration of Zn on the basis of $\ell = 0$ to (n + 1)

Ans. $\ell = 0$ to n + 1

$1\ s^2 1p^6 1\ d^{10}$

$2\ s^2 2p^6 2\ d^2 2f$

$3\ s^2 3p\ 3d\ 3f\ 3g$

SCREENING EFFECT (σ) AND EFFECTIVE NUCLEAR CHARGE (Z_{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.

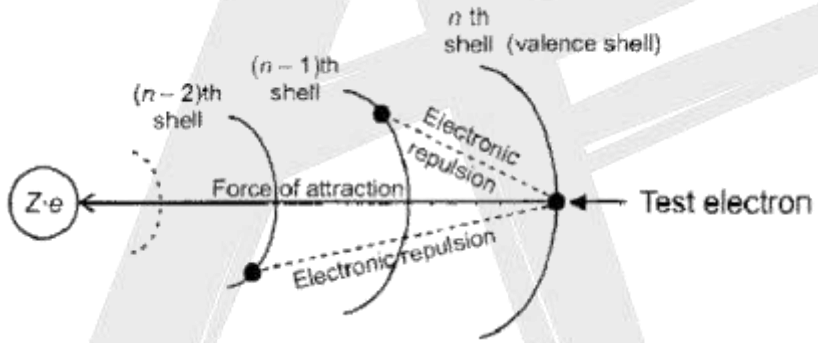
(d) Due to screening effect, net attractive force felt by the electron is measured by effective nuclear charge, (Z_{eff})

(e) If nuclear charge = Z, then effective nuclear charge = $Z - \sigma$

(Where σ 'sigma' is called screening/shielding constant)

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

$\boxed{\text{Attraction} - \text{Repulsion} = \text{Net attraction}}$



➢ **CALCULATION OF σ** (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 :** 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)

(b) All of the other electrons in the (ns, np) group, shield the concern electron to an extent of 0.35 each. (Except for the 1 s orbital for which value is 0.30).

(c) All electrons in the (n − 1) shell shield to an extent of 0.85 each.

(d) All electrons (n − 2) or lower group shield completely; that is, their contribution is 1.00 each.

- **For d and f electrons :**

(e) Electrons in any group to the right of the nd or nf group contribute nothing to the shielding constant.

(f) All the other electrons in the nd or nf group, except the test electron shield the valence electron to an extent of 0.35 each.

(g) All electrons in groups lying to the left of the nd or nf group contribute 1.00.

(Effective Nuclear charge of elements of second period)

Element	Electronic Configuration	Z Atomic number	σ of ns & np electron (a)	$\sigma(n-1)$ Orbital (b)	Total Screening Constant (a+ b)	Effective Nuclear Charge# $Z^* = Z - \sigma$
$_3Li$	$1s^2, 2s^1$	3	-	$0.85 \times 2 = 1.70$	1.70	1.30
$_4Be$	$1s^2, 2s^2$	4	$1 \times 0.35 = 0.35$	$0.85 \times 2 = 1.70$	2.05	1.95
$_5B$	$1s^2, 2s^2, 2p^1$	5	$2 \times 0.35 = 0.70$	$0.85 \times 2 = 1.70$	2.40	2.60
$_6C$	$1s^2, 2s^2, 2p^2$	6	$3 \times 0.35 = 1.05$	$0.85 \times 2 = 1.70$	2.75	3.25
$_7N$	$1s^2, ss^2, 2p^3$	7	$4 \times 0.35 = 1.40$	$0.85 \times 2 = 1.70$	3.10	3.90
$_8O$	$1s^2, 2s^2, 2p^4$	8	$5 \times 0.35 = 1.75$	$0.85 \times 2 = 1.70$	3.45	4.55
$_9F$	$1s^2, 2s^2, 2p^5$	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 electron 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 :-

Q. 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_{eff} when the atom is ionized to N^+.

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

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

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 $N^+ = (1\,s^2)(2\,s^2 2p^2)$

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 $N^+ = 7 - 2.75 = 4.25$

- Calculation of Z_{eff} for electrons of ns&np for Ar

$Ar - (1s^2)\quad (2s^2 2p^6)\quad (3s^2 3p^6)$

rest $\quad (n-1)^{th}\quad n^{th}$

$= 7 \times 0.35 + 8 \times 0.85 + 2 \times 1$

$\sigma = 11.25$

$Z^* = 18 - 11.25$

$= 6.75$

- Calculation of Z_{eff} for electrons of 3s orbita

$Ar - (1s^2)\quad (2s^2 2p^6)\quad (3s^2 3p^6)$

rest $\quad (n-1)^{th}\quad n^{th}$

$= 7 \times 0.35 + 8 \times 0.85 + 2 \times 1$

$\sigma = 11.25$

$Z^* = 18 - 11.25$

$= 6.75$

- Calculation of Z_{eff} for nd and nf :

Ex:- Z_{eff} for 3 d subshell : Zn $\rightarrow (1s^2 2s^2 2p^6 3s^2 3p^6)\ (3d^{10})\ (4s^2)$

$$18 \times 1 \qquad 9 \times 0.35$$

$$= 9 \times 0.35 + 18 \times 1$$

$$\sigma = 21.15$$

$$Z^* = 30 - 21.15 = 8.85$$

- Calculation of Z_{eff} for 1 s – electron

  Value of σ for values of 1 s = 0.30

  He $= 1s^2$

  $= 1 \times 0.3$

  $\sigma = 0.3$

  $Z^* = 2 - 0.3 = 1.7$

  Some other examples are : H^-, He, Li^+, Be^{2+}

DO YOUR SELF – 4

1. Select the species among the following for which value of spin only magnetic moment will be $4\sqrt{3}$.

(A) Fe (B) Ni (C) Mn (D) Cr

2. Which of the following have identical value of Magnetic moment?

(A) Mn^{+4}, Co^{2+} (B) Co^{+2}, Ni^{+2} (C) Mg^{+2}, Sc^{+2} (D) Sc, V^{2+}

3. Total number of exchange pair for the 2p subshell of nitrogen is

(A) 3 (B) 4 (C) 10 (D) 2

4. Find the Z_{eff} of last electron of Carbon.

(A) 2 (B) 3.25 (C) 2.60 (D) 3.90

5. Value of Z_{eff} of 4 s electron of Sc is.

(A) 4 (B) 3 (C) 2 (D) 1

EXERCISE – I

GENERAL INTRODUCTION

1. Which of the following pairs of the species are isoelectronic as well as isotopic?
(Atomic number of Ca = 20, Ar = 18, K = 19, Mg = 12, Fe = 26, Na = 11)
(A) $^{40}Ca^{+2}$, ^{40}Ar (B) $^{39}K^{+}$, $^{40}K^{+}$ (C) $^{24}Mg^{2+}$, ^{25}Mg (D) ^{23}Na, $^{24}Na^{+}$

2. Which among the following is an example of pure element?
(A) Steel (B) Air (C) Brass (D) Graphite

3. Identify the set of isoelectronic species:
(A) N^{3-}, O^{2-}, F (B) N, O, F (C) H, H^{+}, H^{-} (D) H^{-}, Li, Be

4. An atom has 8 electron, 10 neutron and 8 protons. Which is the isotope of given atom?
(A) $_{9}F^{19}$ (B) $_{6}C^{14}$ (C) $_{8}F^{18}$ (D) None of these

5. Which of the following set of compound is isoelectronic?
(A) $NO_2^+ \& NO_2^-$ (B) $CO_3^{-2} \& NO_2^+$ (C) $CO_2 \& NO_2^+$ (D) $HCO_3^- \& HSO_4^-$

6. Which of the following pair is isoster?
(A) $N_2O \& H_2O$ (B) $CO_2 \& H_2O$ (C) $N_2O \& CO_2$ (D) NO&CO

7. Which of the following can not be isoelectronic?
(A) two different cations (B) two different anions
(C) different cation & anion (D) two different atoms

8. An isotone of $^{76}_{32}Ge$ is?
(A) $^{79}_{34}Se$ (B) $^{77}_{33}As$ (C) $^{73}_{31}Ga$ (D) None of these

9. Find the total number of exchanges in d^7 configuration:-
(A) 7 (B) 10 (C) 6 (D) 11

10. Total number of degeneracies in N shell in Li^{+2} ion are:-
(A) 16 (B) 9 (C) 3 (D) 6

QUANTUM NUMBER

11. Which of the following pair of electron is excluded from an atom
(A) $n = 2, l = 1, m = +1, s = +\frac{1}{2}$ & $n = 2, l = 1, m = -1, s = -\frac{1}{2}$
(B) $n = 2, l = 0, m = 0, s = +\frac{1}{2}$ & $n = 2, l = 0, m = 0, s = +\frac{1}{2}$
(C) $n = 1, l = 0, m = 0, s = +\frac{1}{2}$ & $n = 1, l = 0, m = 0, s = -\frac{1}{2}$
(D) $n = 3, l = 2, m = -2, s = +\frac{1}{2}$ & $n = 3, l = 0, m = 0, s = +\frac{1}{2}$

12. Which one of the following represents an acceptable set of quantum numbers for an electron in an atom? (arranged as n, l, m_l and m_s)

(A) $5,4,-5,1/2$ (B) $1,0,0,1/2$ (C) $2,2,-1,-1/2$ (D) $3,3,3,1/2$

13. Which quantum number determines the energy of an electron in a hydrogen atom?

(A) l (B) n (C) n and l both (D) m_i

14. The highest probability of finding the electron in an orbital having values of quantum numbers $n = 3, l = 1$ and $m = -1$.

(A) In between any two axis out of three

(B) On any two axis simultaneously, perpendicular to each other

(C) On any one axis out of the three at a time

(D) On all the three axis simultaneously at a time

15. Find the group of orbitals in which atleast one common nodal plane is present:

(A) $2p_x, 3\ d_{xy}, 4\ d_{yz}$ (B) $2p_y, 3\ d_{xy}, 4\ d_{yz}$

(C) $2p_z, 3\ d_{xy}, 4\ d_{yz}$ (D) $4d_{x^2-y^2}, 5d_{z^2}$

16. The electrons, identified by quantum number n and l :

(i) $n = 3: l = 0$ (ii) $n = 5: l = 2$ (iii) $n = 2: l = 1$ (iv) $n = 4: l = 3$

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

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

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

17. Which of the following orbital have nodal plane in yz plane?

(A) p_z (B) p_y (C) d_{xy} (D) d_{yz}

18. Total number of orbitals in a shell are 16, find total no. of orbitals which have $m = 0$ in that shell.

(A) Four (B) Two (C) Eight (D) Six

19. Assume the set of four quantum no. for last electron of an element X in ground state is $n = 4$, $l = 1, m = 1 \& s = -1/2$. and spin multiplicity of element X in its ground state is 4. Identify the element X.

(A) Ga (B) Ge (C) As (D) Se

20. If an electron has spin quantum number of $+\frac{1}{2}$ and magnetic quantum number is -1 it cannot be present in

(A) f-orbital (B) d-orbital (C) p-orbital (D) s-orbital

21. Calculate the total number of electron for Mn having $n + l + m = 2$.

(A) 3 (B) 4 (C) 5 (D) 6

EFFECTIVE NUCLEAR CHARGE (Z_{eff})

22. Which of the following has maximum value of Z_{eff} :

(A) F (B) Cl (C) Br (D) All equal

23. If Z_{eff} of $F(Z = 9)$ is X and Z_{eff} of $Li(Z = 3)$ is Y then find the value of $|X - Y|$

(A) 4.90 (B) 3.90 (C) 2.90 (D) 1.90

24. Which of the following element is having same value of Z_{eff} for electrons of 3 d and 4 s orbital.

(A) Sc (B) Cr (C) Co (D) Ni

25. If Z_{eff} of $N(Z = 7)$ is X and Z_{eff} of $C(Z = 6)$ is Y then find the value of $X + Y$

(A) 4.90 (B) 7.15 (C) 2.90 (D) 1.90

ELECTRONIC CONFIGURATION

26. The percentage of orbitals occupied by electron out of total orbitals present upto the outermost shell of Fe atom:

(A) 50% (B) 70% (C) 25% (D) 35%

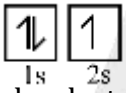
27. The total number of unpaired electrons in the element $(Z = 24)$ in its lowest energy states?

(A) 1 (B) 5 (C) 4 (D) 6

28. Which of the following is violation of $(n + l)$ rule.

(A) 

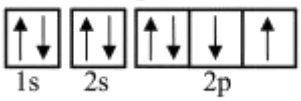
(B) 

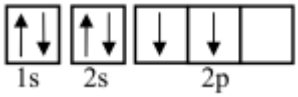
(C) 

(D) 

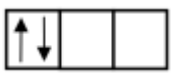
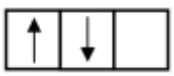
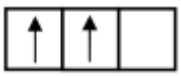
29. Which electronic configuration represents CORRECT ground state electronic configuration:

(A) $1s^2, 2s^1, 2p^6, 3s^1$ (B) $1\,s^2, 2\,s^2, 3\,s^2, 3p^2$

(C) 

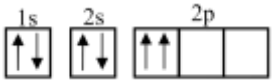
(D) 

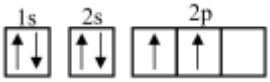
30. The electronic configuration of a carbon $1\,s^2, 2\,s^2, 2p^2$ and consider the following three arrangements of the 2p electrons. Which arrangements have lowest energy?

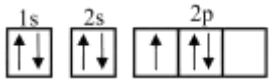
(A)  (B)  (C)  (D) 

31. Which electronic configuration represents a violation of Hund's rule and Pauli's rule both for an atom in its ground state?

(A) 

(B) 

(C) 

(D) 

32. Number of elements/ions given below which contains only one electron in their outer most shell?

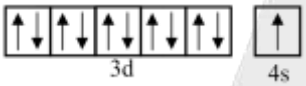
$Rb^{+}, Sr^{+2}, H, Cr, Hg^{+}, Mn^{+2}, P^{+3}, N^{+4}$

(A) 1 (B) 2 (C) 5 (D) 4

33. Select the correct ground state electronic configuration of the element with atomic number 47 is:

(A) $[Ar]3d^9\ 4s^2$

(B) $1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 3d^{10}, 4s^2$

(C) [Ar] 

(D) $[Kr]4d^{10}\ 5s^1$

34. In Mn, the minimum number of electrons having $m_s = -\frac{1}{2}$ is –

(A) 10 (B) 12 (C) 13 (D) 15

35. If Aufbau rule is not followed, $K - 19$ will be placed in

(A) s-block (B) p-block (C) d-block (D) f-block

EXERCISE – II

GENERAL INTRODUCTION

1. Which among the following are isodiapher with $_{17}Cl^{35}$:-

(A) $_{19}K^{39}$ (B) $_{9}F^{19}$ (C) $_{13}Al^{27}$ (D) $_{3}Li^{7}$

2. Which of the following is/are heterogeneous mixture?

(A) Blood (B) Milk (C) Air (D) Tap water

QUANTUM NUMBER

3. Which of the following statement (s) is/are correct about the element having atomic No. 24:

(A) $l = 2$ is possible for an electron in this atom

(B) Total number of electrons having value of magnetic quantum number $|m| = 2$ are two.

(C) Total number of electrons having $|m| = 1$ are ten.

(D) $n = 4, l = 0, m = 0, s = +1$ is impossible set of quantum number for outermost electron.

4. Which of the following set(s) of quatum number is/are invalid for any electron in the ground state electronic configuration of all the elements upto atomic number 18?

	n	l	m	s
(A)	3	2	-1	$+1/2$
(B)	2	2	$+1$	$-1/2$
(C)	4	0	0	$+1/2$
(D)	4	1	-1	$+1/2$

5. All the obitals of a given subshell have the same value of:

(A) principle quantum number (n) (B) azimuthal quantum number (l)

(C) magnetic quantum number (m) (D) none of these

6. For an electron magnetic quantum number $= +2$. The electron may be present in:

(A) 4 s-orbital (B) 4p-orbital (C) 4 d-orbital (D) 4f-orbital

7. Which of the set of quantam number is/are not correct for any electron in ground state electronic configuration of the elements upto atomic no. 30?

	n	l	m	s
(A)	4	0	0	$+1/2$
(B)	3	2	-2	$-1/2$
(C)	3	1	$+2$	$+1/2$
(D)	4	1	-2	$+1/2$

8. Which of the following is/are a valid set of four quantum number (n, l, m_b, m_s) :-

(A) $3,2,-2,+\frac{1}{2}$ (B) $2,0,0,-\frac{1}{2}$ (C) $3,3,-1,+\frac{1}{2}$ (D) $4,3,-3,-\frac{1}{2}$

9. Select the INCORRECT statement (s):

(A) In $d_{x^2-y^2}$ orbital, 2 nodal planes are in xz and yz plane

(B) d_{xy} and p_z has one common nodal plane

(C) $m = -2$ for 4 d subshell is not possible as $n = 4$

(D) number of electrons in subshell $= 2(2\ell + 1)$

10. Which of the following statement(s) is/are CORRECT?

(A) Total number of maximum electrons which can have $n = 5, s = +1/2$ and $n = 5, s = -1/2$ are same.

(B) In H-like atoms, the shells and subshells of a shell have same energies.

(C) The energy order of subshells in only multielectronic atom is decided by $(n + l)$ rule.

(D) The energy order of subshells in single electron species is decied by $(n + l)$ rule.

ELECTRONIC CONFIGURATION

11. Total number of vacant orbitals in the valency shell of that atom which have total s electrons and total p electrons are in same number in its ground state electronic configuration.

(A) Zero (B) Five (C) Four (D) Eight

12. Which of the following subshells are involved for 6^{th} period elements in periodic table?

(A) 4f (B) 5 d (C) 6 s (D) 5p

13. Which electronic configuration represents an atom in its ground state configuration and having completed 3^{rd} principle energy level?

(A) $2-8-6-2$ (B) $2-8-10-2$

(C) $2-8-18-8-1$ (D) $2-8-18-3$

14. Which of the following statement (s) is/are INCORRECT?

(A) Number of electrons having $l = (0)$ is 10 in Pd.

(B) Number of electron in d subshell of Cr and Mn are the same.

(C) Multiplicity of Fe is equal to that of Ni^{2+}

(D) Value of l/n for last electron of element having atomic number 57 is 0.4.

15. Which of the following order of paramagnetism is/are INCORRECT?

(A) $Cr > Fe > Ni > Cu$ (B) $Cr > Ni > Fe > Cu$

(C) $Mg < Al < O < N$ (D) $N < O < Al < Mg$

16. Which of the following pair(s) of species is/are having different value of magnetic moment?

(A) Mn^{2+}&Na^{+} (B) Co^{3+}&Fe^{3+} (C) Zn^{2+}&Cl (D) Zn^{2+}&Na^{+}

EFFECTIVE NUCLEAR CHARGE (Z_{eff})

17. Effective nuclear charge in As(Z = 33) is 6.30. Which of following is/are correct:

(A) 4 s electron (B) 4p electron (C) 3 d electron (D) Outermost electron

18. Which of the following option is CORRECT ?

Element/ion	Z_{eff}	Element/ion	Z_{eff}
(A) $_{55}Cs$	2.2	(B) $_{21}Sc^{+2}$	18
(C) $_{9}F$	5.20	(D) $_{10}Ne$	4.15

19. Using the slater's rule, choose the incorrect statements among the following.

(A) Value of σ (shielding constant) for d-electrons of penultimate shell of Sc, Y, La are equal.

(B) Z_{eff} for d-electrons of penultimate shell of Sc, Y, La are equal.

(C) Value of σ increases by a factor of 0.3 in the second period from left to right.

(D) Value of Z_{eff} increases by a factor of 0.35 in the second period from left to right.

20. Select the correct relationship (Z_{eff} for the last electron):

(A) $Z_{eff}(Na^{+}) < Z_{eff}(Mg^{+2})$ (B) $Z_{eff}(He) < Z_{eff}(Be^{+2})$

(C) $Z_{eff}(Mg) = Z_{eff}(Ca)$ (D) $Z_{eff}(Al^{+3}) < Z_{eff}(Na^{+})$

EXERCISE – III

Integer Answer Type (0 to 9):

1. What is the minimum value of n (principal quantum number) is possible for magnetic quantum number $m = -2$ and $s = +\frac{1}{2}$?

2. Find the total number of electron in Cr which have $(n \times l) =$ zero.

3. Total number exchange are possible for 3 d^4 electronic configuration.

4. Find the total number of orbital(s) in iron having $|m| < 1$ and atleast one electron is present in orbital.

5. Find the sum of total numbers of 5f-electrons in Th and Ac.

6. Total number of electrons in Zn (atomic number $= 30$) for which $n + l + m = 0$

7. Find the number of electron having $(n \times l + m) = 3$ for Kr atom (Atomic number $= 36$)

8. The Z_{eff} on the last electron of Zr^{3+} ion is

9. In the following species, the number of them having same magnetic moment value is

_____ $Fe^{3+}, Co^{3+}, Ni^{2+}, Mn^{3+}, Cu^{+}, Zn^{2+}, Cd^{2+}, Cu^{2+}, Ag^{+}$

10. An element 'X ' has its electronic configuration of ' K ' shell is $(n-5)s^2$ and it has total number of electrons in its outermost, penultimate and antipenultimate shell are 2, 8 and 25 respectively, then find out total number of unpaired electrons in element ' X ' in their ground state.

11. Find the total number of orbitals in which electron density is not observed along any axis (x, y or z). $P_X, P_y, P_z, d_{yz}, d_{xz}, d_{x^2-y^2}, d_z^2, d_{xy}$

12. Find the maximum number of electrons in Cr atom which have $m = -1$ and $s = +\frac{1}{2}$ but $n \neq 2$.

13. Find minimum possible values of missing digits (X, Y, Z) in following set of quantum numbers and calculate sum of X, Y and Z.

	n	l	| m |	s
Set (I) =	5	2	X	$-\frac{1}{2}$
Set (II) =	Y	3	0	$+\frac{1}{2}$
Set (III) =	3	Z	1	$-\frac{1}{2}$

14. Number of unpaired electrons in $Mn^{+7} = a$

Number of d-subshell electrons in $Cr = b$

Number of f-subshell electron in Hf (Atomic number $= 72$) $= c$

Find the value of $c - b + a$?

15. How many subshells are possible in N-shell?

16. Find the number of exchanges of electrons associated to $l = 2$ in nickel.

[Write your answer as sum of digits till you get the single digit answer]

17. The spin only magnetic moment of Mn^{+2} is $\sqrt{x}$ B.M. .The value $\left(\frac{x}{7}\right)$ of

18. Find the number of sets of isosters

$(N_2, CO), (N_2O, CO_2), (HF, OH^-), (B_3\ N_3H_6, C_6H_6)$

EXERCISE – IV

PARAGRAPH FOR QUESTION NUMBER 1 TO 2

Three quantum numbers are required to define an orbital while four quantum numbers are required to describe an electron.

1. $(n + l)$ is maximum and minimum for which of the following orbitals: 6 s, 5p, 4 d, 2p, 3 s, 2 s?

(A) 4 d and 1 s (B) 6 s and 2 s (C) 5p and 3 s (D) 6s and 2p

2. Which of the following statement is correct for H atom?

(A) H atom can be placed both in group 1 and group 18.

(B) H atom can be placed both in Group 1 and Group 17.

(C) H atom produces smallest anion in reality.

(D) 2 s, 2p, 3 s orbitals are not available in H atom

PARAGRAPH FOR QUESTION NUMBER 3 TO 4

Repulsion force by innershell electrons on outer most shell electrons is called shielding effect. Due to shielding effect valence shell electron experiences less force of attraction by nucleus. (i.e. total attraction force experienced by valence electron is called effective nuclear charge) $Z_{eff.} = Z - \sigma$

Where : $Z_{eff.}$ = effective nuclear charge Z = atomic number

σ = shielding constant

3. Select the correct effective nuclear charge on outermost electron in C.

(A) 2.75 (B) 2.40 (C) 3.25 (D) 0.85

4. Calculate the screening constant for 4 s electron of Zn ?

(A) 4.6 (B) 21.5 (C) 25.65 (D) 5.6

PARAGRAPH FOR QUESTION NUMBER 5 TO 6

Many elements and compounds exhibit magnetic property because of presence of unpaired electrons.

5. Which of the following species is diamagnetic in nature?

(A) Fe^{2+} (B) Zn^{2+} (C) Fe^{3+} (D) Co^{3+}

6. Which species has the same spin multiplicity as that of Mn^{2+}?

(A) Cr + (B) Fe^{3+} (C) Co^{4+} (D) All of these

PARAGRAPH FOR QUESTION NUMBER 7 TO 8

In a hypothetical system all the known concept of shell, subshell, orbitals etc. exist in the same way as in our system except that the $(n + l)$ rule is modified to $(n - l)$ rule for deciding the subshell energy. In case of equal value of $(n - l)$, the higher value of ' n ' gives the higher energy.

7. In this hypothetical system S($Z = 16$) will be a

(A) p-block element

(B) s-block element

(C) d-block element

(D) f-block element

8. For $n \leq 3$; the subshell having maximum energy for the above hypothetical system will be:

(A) 2 s (B) 3 d (C) 3p (D) 3 s

MATRIX MATCH TYPE

9.

Column I	**Column II**
(A) $2(2l + 1)$	(P) number of orbitals in subshell.
(B) n^2	(Q) value of shell in an atom
(C) n	(R) number of electron in subshell.
(D) $(2l + 1)$	(S) number of orbitals in shell
	(T) number subshell in shell.

10.

Column I	**Column II**
(A) Isobars	(P) $_{17}Cl^{37}$ & $_{21}Sc^{45}$
(B) Isoelectronics	(Q) $_{18}Ar^{40}$ & $_{20}Ca^{40}$
(C) Isodiaphers	(R) $_{12}Mg^{24}$ & $_{11}Na^{23}$
(D) Isotones	(S) SiO_4^{-4} & SO_4^{-2}

11.

Column I **(Elements)**	**Column II** **(Z_{eff} experienced by outer most electron)**
(A) C	(P) 5.85
(B) O	(Q) 2.2
(C) Na	(R) 3.25
(D) Ne	(S) 4.55

EXERCISE – JEE-MAIN

1. The electrons identified by quantum numbers n and ℓ :-

[JEE-1999, JEE-MAIN, (ONLINE)-2012]

(a) $n = 4, \ell = 1$ (b) $n = 4, \ell = 0$ (c) $n = 3, \ell = 2$ (d) $n = 3, \ell = 1$

Can be placed in order of increasing energy as

(A) (a) < (c) < (b) < (d) (B) (c) < (d) < (b) < (a)

(C) (d) < (b) < (c) < (a) (D) (b) < (d) < (a) < (c)

2. Which of the following paramagnetic ions would exhibit a magnetic moment (spin only) of the order of 5 B.M.? **[JEE-MAIN, (ONLINE)-2012]**

(At. No: $Mn = 25, Cr = 24, V = 23, Ti = 22$)

(A) V^{2+} (B) Ti^{2+} (C) Mn^{2+} (D) Cr^{2+}

3. In an atom how many orbital (s) will have the quantum numbers; $n = 3, l = 2$ and $m_l = +2$?

[JEE-MAIN, (ONLINE)-2013]

(A) 1 (B) 5 (C) 3 (D) 7

4. The numbers of protons, electrons and neutrons in a molecule of heavy water are respectively

[JEE-MAIN, (ONLINE)-2013]

(A) 10,10,10 (B) 8,10,11 (C) 10,11,10 (D) 11,10,10

5. Given

(A) $n = 5,\ m_l = +1$ (B) $n = 2, l = 1,\ m_l = -1,\ m_s = -l/2$

The maximum number of electron(s) in an atom that can have the quantum numbers as given in (A) and (B) are respectively: **[JEE-MAIN, (ONLINE)-2013]**

(A) 8 and 1 (B) 25 and 1 (C) 2 and 4 (D) 4 and 1

6. The correct set of four quantum numbers for the valence electrons of rubidium atom ($Z = 37$) is:

[JEE-MAIN, (ONLINE)-2014]

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

7. If the principal quantum number $n = 6$, the correct sequence of filling of electrons will be:-

[JEE-MAIN, (ONLINE)-2015]

(A) $ns \rightarrow (n-1)d \rightarrow (n-2)f \rightarrow np$ (B) $ns \rightarrow np \rightarrow (n-1)d \rightarrow (n-2)f$

(C) $ns \rightarrow (n-2)f \rightarrow (n-1)d \rightarrow np$ (D) $ns \rightarrow (n-2)f \rightarrow np \rightarrow (n-1)d$

8. The total number of orbitals associated with the principal quantum number 5 is:

[JEE-MAIN, (ONLINE)-2016]

(A) 25 (B) 5 (C) 20 (D) 10

9. The 71^{st} electron of an element X with an atomic number of 71 enters into the orbital:

[JEE-MAIN, (ONLINE)-2019]

(A) 6p (B) 6 s (C) 5 d (D) 4f

10. The value of magnetic quantum number of the outermost electron of Zn^{+}ion is _____ .

[JEE-MAIN – 2021]

11. Ge($Z = 32$) in its ground state electronic configuration has x completely filled orbitals with $m_l = 0$. The value of x is _____ . **[JEE-MAIN – 2021]**

12. The Azimuthal quantum number for the valence electrons of Ga^{+} ion is ___ . **[JEE-MAIN – 2021]**

(Atomic number of Ga =31)

13. Which one of the following species doesn't have a magnetic moment of 1.73BM, (spin only value)?

[JEE-MAIN – 2021]

(A) O_2^+ (B) CuI (C) $[Cu(NH_3)_4]Cl_2$ (D) O_2^-

14. The spin only magnetic moments (in BM) for free Ti^{3+}, V^{2+} and Sc^{3+} ions respectively are (At. No. Sc : 21, Ti: 22, V: 23) **[JEE-MAIN – 2021]**

(A) 3.87,1.73,0 (B) 1.73,3.87,0 (C) 1.73,0,3.87 (D) 0,3.87,1.73

15. The number of orbitals with $n = 5,\ m_1 = +2$ is _____ . **[JEE-MAIN – 2021]**

(Round off to the Nearest Integer).

16. What is the spin-only magnetic moment value (BM) of a divalent metal ion with atomic number 25, in it's aqueous solution? **[JEE-MAIN – 2021]**

(A) 5.92 (B) 5 (C) zero (D) 5.26

17. A certain orbital has $n = 4$ and $m_L = -3$. The number of radial nodes in this orbital is (Round off to the Nearest Integer). **[JEE-MAIN – 2021]**

18. In the ground state of atomic Fe($Z = 26$), the spin-only magnetic moment is $\times 10^{-1}$BM. (Round off to the Nearest Integer). **[JEE-MAIN – 2021]**

[Given : $\sqrt{3} = 1.73, \sqrt{2} = 1.41$]

19. A certain orbital has no angular nodes and two radial nodes. The orbital is: **[JEE-MAIN – 2021]**

(A) 2 s (B) 3 s (C) 3p (D) 2p

20. Consider the following pairs of electrons **[JEE-MAIN – 2022]**

(A) (a) $n = 3, 1 = 1, m_l = 1, m_s = +\frac{1}{2}$ (b) $n = 3, l = 2, m_1 = 1, m_s = +\frac{1}{2}$

(B) (a) $n = 3, 1 = 2, m_1 = -2, m_s = -\frac{1}{2}$ (b) $n = 3, l = 2, m_1 = -1, m_s = -\frac{1}{2}$

(C) (a) $n = 4, 1 = 2, m_1 = 2, m_s = +\frac{1}{2}$ (b) $n = 3, l = 2, m_1 = 2, m_s = +\frac{1}{2}$

The pairs of electron present in degenerate orbitals is/are:

(A) Only A (B) Only B (C) Only C (D) (B) and (C)

21. The pair, in which ions are isoelectronic with Al^{3+} is :- **[JEE-MAIN – 2022]**

(A) Br^- and Be^{2+} (B) Cl^- and Li^+

(C) S^{2-} and K^+ (D) O^{2-} and Mg^{2+}

22. The number of radial and angular nodes in 4 d orbital are. respectively **[JEE-MAIN – 2022]**

(A) 1 and 2 (B) 3 and 2 (C) 1 and 0 (D) 2 and 1

23. Consider the following set of quantum numbers **[JEE-MAIN – 2022]**

	n	1	m_1
(A)	3	3	-3
(B)	3	2	-2
(C)	2	1	+1
(D)	2	2	+2

The number of correct sets of quantum numbers is _____ .

24. Consider the following statements : **[JEE-MAIN – 2022]**

(A) The principal quantum number ' n ' is a positive integer with values of ' n ' = 1,2,3, ...

(B) The azimuthal quantum number ' l ' for a given ' n ' (principal quantum number) can have values as $'l' = 0,1,2, \ldots . n$

(C) Magnetic orbital quantum number ' m_l ' for a particular ' l ' (azimuthal quantum number) has (2l + 1) values.

(D) $\pm 1/2$ are the two possible orientations of electron spin.

(E) For $l = 5$, there will be a total of 9 orbital.

Which of the above statements are correct?

(A) (A), (B) and (C) (B) (A), (C), (D) and (E)

(C) (A), (C) and (D) (D) (A), (B), (C) and (D)

25. Which of the following statements are correct? **[JEE-MAIN – 2022]**

(A) The electronic configuration of Cr is $[Ar]3d^5\ 4s^1$

(B) The magnetic quantum number may have a negative value.

(C) In the ground state of an atom, the orbitals are filled in order of their increasing energies.

(D) The total number of nodes are given by $n - 2$.

Choose the most appropriate answer from the options given below :

(A) (A), (C) and (D) only (B) (A) and (B) only

(C) (A) and (C) only (D) (A), (B) and (C) only

26. Which of the following sets of quantum numbers is not allowed ? **[JEE-MAIN – 2022]**

(A) $n = 3, l = 2, m_l = 0, s = +\frac{1}{2}$ (B) $n = 3, l = 2, m_l = -2, s = +\frac{1}{2}$

(C) $n = 3, l = 3, m_l = -3, s = -\frac{1}{2}$ (D) $n = 3, l = 0, m_l = 0, s = -\frac{1}{2}$

27. The correct decreasing order of energy, for the orbitals having, following set of quantum numbers:

(A) $n = 3, l = 0, m = 0$ (B) $n = 4, l = 0, m = 0$ **[JEE-MAIN – 2022]**

(C) $n = 3, l = 1, m = 0$ (D) $n = 3, l = 2, m = 1$

(A) (D) > (B) > (C) > (A) (B) (B) > (D) > (C) > (A)

(C) (C) > (B) > (D) > (A) (D) (B) > (C) > (D) > (A)

28. The number of subshells associated with n = 4 and m = - 2 quantum numbers is **[JEE-MAIN – 2020]**

(A) 2 (B) 8 (C) 4 (D) 16

29. Consider the hypothetical situation where the azimuthal quantum number, I, takes value 0,1, 2, ...n + 1, where n is the principal quantum number. Then, the element with atomic number **[JEE-MAIN – 2020]**

(A) 9 is the first alkali metal (B) 6 has a 2 p-valence subshell

(C) 8 is the first noble gas (D) 13 has a half-filled valence subshell

30. In the sixth period, the orbitals that are filled are **[JEE-MAIN – 2020]**

(A) 6s, 4f, 5d, 6p (B) 6s, 5d, 5f, 6p

(C) 6s, 6p, 6d, 6f (D) 6s, 5f, 6d, 6p

31. The number of oribtals associated with quantum number $n = 5, m_s = +\frac{1}{2}$ **[JEE-MAIN – 2020]**

(A) 25 (B) 30 (C) 50 (D) 35

32. The number of s-electrons present in an ion with 55 protons in its unipositive state is _____ .

[JEE-MAIN – 2023]

(A) 8 (B) 9 (C) 12 (D) 10

33. How many of the following metal ions have similar value of spin only magnetic moment in gaseous state?

[JEE-MAIN – 2023]

(Given: Atomic number : V, 23; Cr, 24; Fe, 26; Ni, 28)

$V^{3+} \cdot Cr^{3+}, Fe^{2+}, Ni^{3+}$

34. Maximum number of electrons that can be accommodated in shell with n = 4 are:

[JEE-MAIN – 2023]

(A) 16 (B) 32 (C) 50 (D) 72

35. Arrange the following orbitals in decreasing order of energy?

[JEE-MAIN – 2023]

(A) $n = 3, l = 0, m = 0$ (B) $n = 4, l = 0, m = 0$

(C) $n = 3, l = 1, m = 0$ (D) $n = 3, l = 2, m = 1$

The correct option for the order is :

[JEE-MAIN – 2023]

(A) $B > D > C > A$ (B) $D > B > C > A$

(C) $A > C > B > D$ (D) $D > B > A > C$

36. Which one of the following sets of ions represents a collection of isoelectronic species?

(Given : Atomic Number : F: 9, Cl: 17, $Na = 11, Mg = 12, Al = 13, K = 19, Ca = 20, Sc = 21$)

[JEE-MAIN – 2023]

(A) $Li^+, Na^+, Mg^{2+}, Ca^{2+}$ (B) $Ba^{2+}, Sr^{2+}, K+, Ca^{2+}$

(C) $N^{3-}, O^{2-}, F^-, S^{2-}$ (D) $K^+, Cl^-, Ca^{2+}, Sc^{3+}$

EXERCISE – JEE-ADVANCE

1. The electronic configuration of an element is $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5 4s^1$. This represents its: **[JEE- 2000]**

(A) excited state (B) ground state

(C) cationic form (D) none

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

3. 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]**

4. Not considering the electronic spin the degeneracy of the second excited state ($n = 3$) of H-atom is 9, what will be the degeneracy of the second excited state of H^- is **[JEE Advanced- 2015]**

ANSWER KEY

DO YOUR SELF – 1

1. (C) 2. (A) 3. (C) 4. (D) 5. (B)

DO YOUR SELF – 2

1. (B) 2. (A) 3. (A) 4. (D) 5. (D) 6. (A) 7. (A)

DO YOUR SELF – 3

1. (A) 2. (B) 3. (B) 4. (D) 5. (B) 6. (C) 7. (B)

DO YOUR SELF – 4

1. (D) 2. (A) 3. (A) 4. (B) 5. (B)

EXERCISE–I

1. (B) 2. (D) 3. (A) 4. (D) 5. (C) 6. (C) 7. (D)
8. (B) 9. (D) 10. (A) 11. (B) 12. (B) 13. (B) 14. (C)
15. (B) 16. (A) 17. (C) 18. (A) 19. (C) 20. (D) 21. (B)
22. (C) 23. (B) 24. (A) 25. (B) 26. (A) 27. (D) 28. (B)
29. (D) 30. (C) 31. (B) 32. (D) 33. (D) 34. (A) 35. (C)

EXERCISE–II

1. (ABCD) 2. (ABD) 3. (ABCD) 4. (AB) 5. (AB)
6. (CD) 7. (CD) 8. (ABD) 9. (ABC) 10. (AC) 11. (AD)
12. (ABC) 13. (CD) 14. (AC) 15. (BD) 16. (ABC) 17. (ABC) 18. (AC)
19. (ACD) 20. (ABC)

EXERCISE–III

1. (3) 2. (7) 3. (6) 4. (7) 5. (0) 6. (0) 7. (6)
8. (4) 9. (4) 10. (7) 11. (3) 12. (2) 13. (4) 14. (9)
15. (4) 16. (4) 17. (5) 18. (4)

EXERCISE–IV

1. (B) 2. (B) 3. (C) 4. (C) 5. (B) 6. (D) 7. (C)
8. (D)
9. (A) → R; (B) → S; (C) → Q, T; (D) → P
10. (A) → Q; (B) → S; (C) → P; (D) → R;
11. (A) → R; (B) → S; (C) → Q; (D) → P

EXERCISE # JEE-MAIN

1.	(C)	2.	(C)	3.	(A)	4.	(A)	5.	(A)	6.	(C)	7.	(C)
8.	(A)	9.	(C)	10.	(0)	11.	(7)	12.	(0)	13.	(B)	14.	(B)
15.	(3)	16.	(A)	17.	(0)	18.	(49)	19.	(B)	20.	(B)	21.	(D)
22.	(A)	23.	(B)	24.	(C)	25.	(D)	26.	(C)	27.	(A)	28.	(B)
29.	(D)	30.	(A)	31.	(A)	32.	(D)	33.	(2)	34.	(B)	35.	(B)
36.	(D)												

EXERCISE # JEE-ADVANCE

1.	(BC)	2.	(9)	3.	(6)	4.	(3)