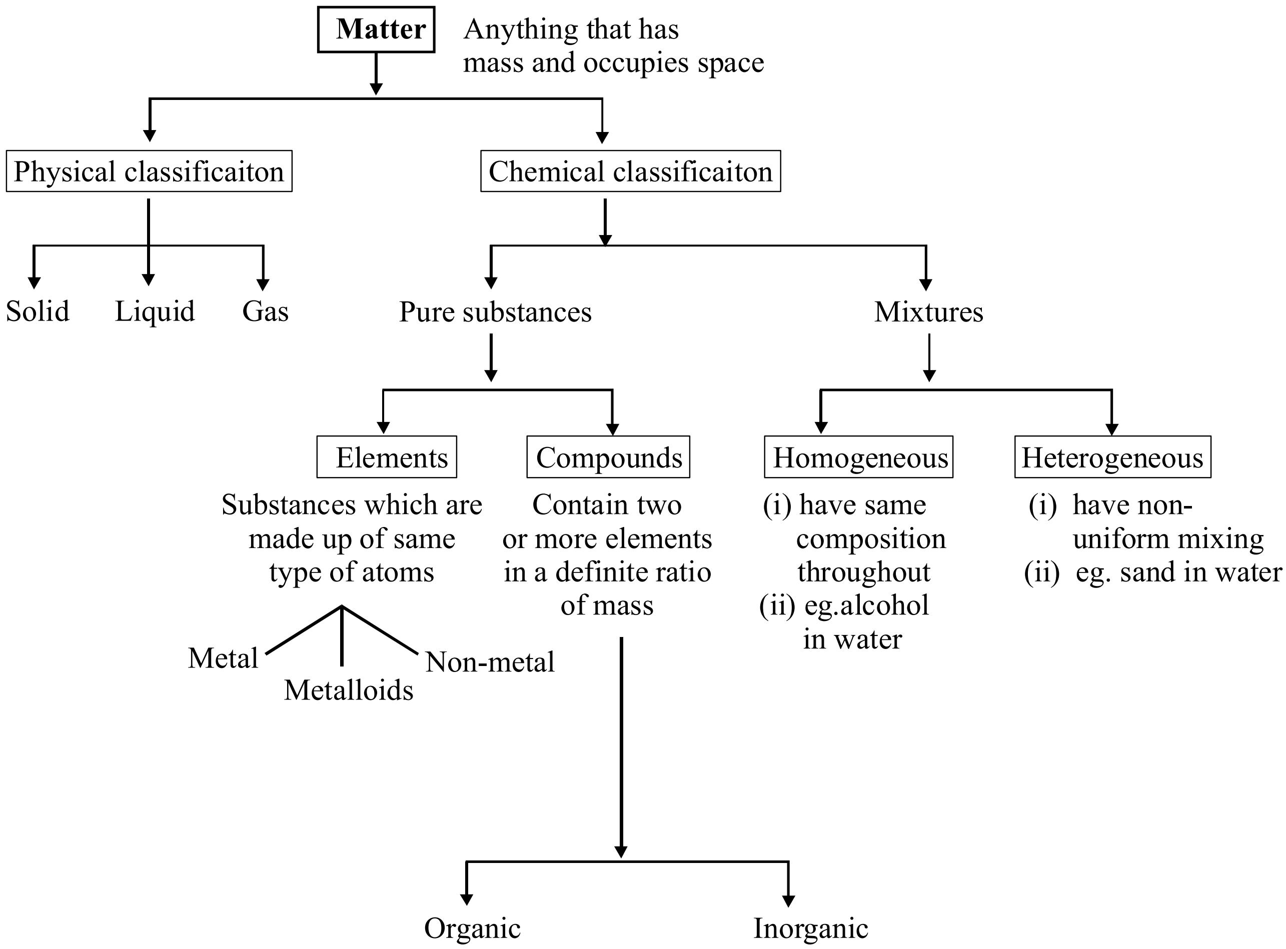
QUANTUM NUMBER & ELECTRONIC CONFIGURATION

MATTER & ITS CLASSIFICATION



Example.1 Which of the following is homogeneous mixture :

(A) Oil + Water (B) Milk

(C) Salt dissolved in water (D) All of these

Example.2 Which of the following molecule is tetra-atomic :

(A) CH_2Cl_2 (B) NH_3 (C) H_2O (D) Both (B) and (C)

ATOM : An atom is the smallest particle of an element (made up of still smaller particle like electrons, protons, neutrons etc.) which can take part in a chemical reaction. It may or may not exist free in nature.

Name of particle	Mass	Nature of charge	Amount of charge	Presence in the atom
(i) Electron symbol = (e) Notation = $_{-1}e^{\circ}$ 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	Positively charged	$+ 1.602 \times 10^{-19}$ coulomb $+ 4.8 \times 10^{-10}$ e.s.u.	Inside the nucleus of an atom
(ii) Neutron symbol = (n) Notation = ($_0n^1$) Discoverer J. Chadwick (1932)	1.675×10^{-24} g	Neutral	0	Inside the nucleus of an atom

Representation of atom : $_ZX^A$

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.)

⇒ ***Isotope :*** Atoms of given element which have same atomic number but different mass number are called isotope : e.g. $_1H^1$, $_1H^2$, $_1H^3$ 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-electronic species :*** Species (atom, molecules or ions) having same number of electrons are called iso-electronic e.g H^-, He, Li^+ and Be^{2+} have 2 valence electrons each.

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. eg. N_2O, CO_2

⇒ ***Iso-diaphers :*** Species having same difference in number of neutrons and protons or same number of excess of neutron. eg. $^{19}_{9}F$, $^{23}_{11}Na$

⇒ ***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.

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 of a electron.

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

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 → **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_l) :

(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) OR 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 magnetic spin quantum number represents the direction of electron spin (rotation) around its own axis (clockwise or anticlockwise).

(ii) There are two possible values of $\mathbf{m_s}$ are $+\frac{1}{2}$ & $-\frac{1}{2}$ and represented by the two arrows ↑ (spin up) and ↓ (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)

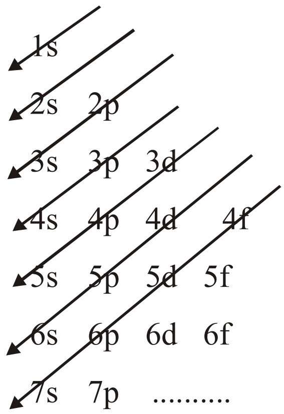
$l = 0, m = 0$

For 1[st] Electron $n = 1, l = 0, m = 0, m_s = +\frac{1}{2}$

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 < 7p

Alternatively, 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.

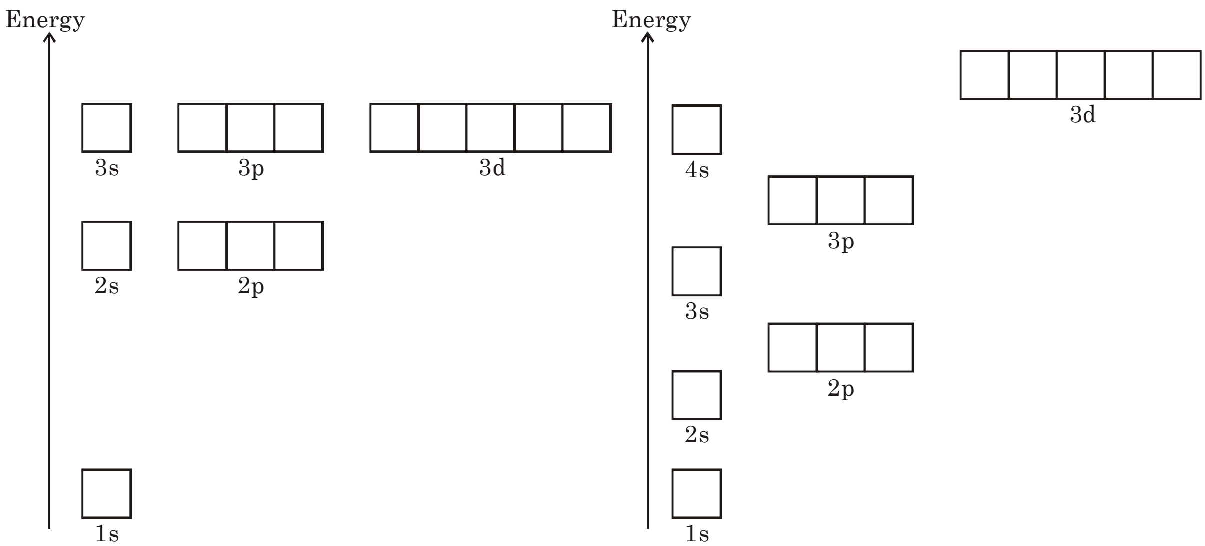
e.g. 2p & 3s

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 .... energy order of different orbitals for single electron system like H, He^{+}, Li^{+2} etc.



(A) For single electron or hydrogenic atom (B) Multi electronic atoms

Energy level diagram for few electronic shells :

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

Ans. For 4s, $n = 4$, $l = 0$, $(n + l) = 4$

For 3p, $n = 3$, $l = 1$, $(n + l) = 4$

For 4p, $n = 4$, $l = 1$, $(n + l) = 5$

For 3d, $n = 3$, $l = 2$, $(n + l) = 5$

$\Rightarrow$ 3p < 4s < 3d < 4p increasing order

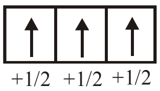
3. Hund's rule of maximum multiplicity :

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"

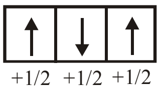
Multiplicity = 2|S| + 1, where S = Total spin.

i.e. 

Find total spin & multiplicity

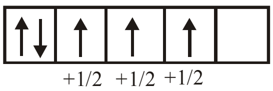
Total spin $S = \frac{1}{2}+\frac{1}{2}+\frac{1}{2}=\frac{3}{2}$

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

i.e. 

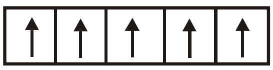
Total spin $S = \frac{1}{2}-\frac{1}{2}+\frac{1}{2}=\frac{1}{2}$

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.

nl^x ← x : no. of electrons in subshell

n (represents shell)

l : represents subshell

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

2 : Second shell

p : p subshell

$_3Li$; $1s^2, 2s^1$ or [He] $2s^1$ or 1s [↑↓] 2s [↑] or [He] 2s [↑]

Electronic configuration :

Example.5 Nitrogen

Ans. $_7N$: $1s^2, 2s^2\ 2p^3$ [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.

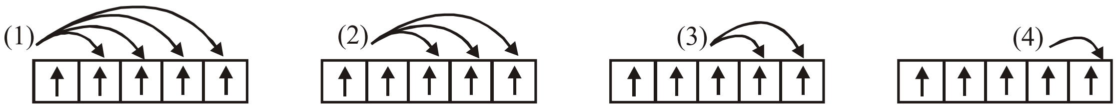
$_{24}Cr \rightarrow$ [Ar] $3d^5, 4s^1$ and not [Ar] $3d^4\ 4s^2$

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

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 is the stability.

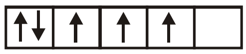


4-exchanges by electron 1 | 3-exchanges by electron 2 | 2-exchanges by electron 3 | 1-exchanges by electron 4

Total exchange pairs = 10

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

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

e.g. 

Only 6 total exchange possible

Exceptional electronic configuration

S.No.	Element	Z	Configuration
1	Cr	24	$[Ar]4s^1 3d^5$
2.	Cu	29	$[Ar]4s^1 3d^{10}$
3.	Nb	41	$[Kr]5s^1 4d^4$
4.	Mo	42	$[Kr]5s^1 4d^5$
5.	Ru	44	$[Kr]5s^1 4d^7$
6.	Rh	45	$[Kr]5s^1 4d^8$
7.	Pd	46	$[Kr]4d^{10}$
8.	Ag	47	$[Kr]5s^1 4d^{10}$
9.	La	57	$[Xe]6s^2 5d^1$
10.	Pt	78	$[Xe]6s^1 4f^{14} 5d^9$
11.	Au	79	$[Xe]6s^1 4f^{14} 5d^{10}$
12.	Ac	89	$[Rn]7s^2 6d^1$
13.	Th	90	$[Rn]7s^2 6d^2$

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 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)

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

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

$\Rightarrow$ 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 4s orbital (outermost).

Electronic configuration of V^{+4}

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

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 & Y axis.
		d_{z^2}	None (two nodal cones are available)

SCREENING EFFECT (s) 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.

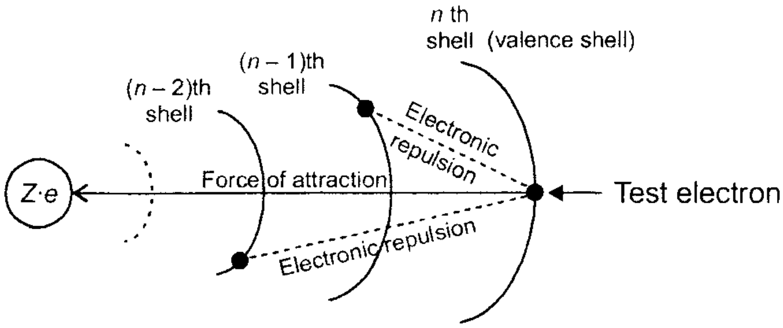
(b) The decrease in force of attraction on valence electron due to inner shell electron is called screening effect or shielding effect.(i.e. total repulsive force is called shielding effect.)

(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 constant/sheilding constant)

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



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 :

(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.

(Effective Nuclear charge of elements of second period)

Element	Electronic Configaration	Z	σ of ns & np electron (a)	σ (n–1) orbital (b)	Total Screeing Constant (a + b)	Effective nuclear charge# Z*=Z – σ
$_3Li$	$1s^2\ 2s^1$	3	–	0.85× 2=1.70	1.70	1.30
$_4Be$	$1s^2, 2s^2$	4	1× 0.35=0.35	0.85× 2=1.70	2.05	1.95
$_5B$	$1s^2,2s^2,2p^1$	5	2× 0.35=0.70	0.85× 2=1.70	2.40	2.60
$_6C$	$1s^2,2s^2,2p^2$	6	3× 0.35=1.05	0.85× 2=1.70	2.75	3.25
$_7N$	$1s^2,2s^2,2p^3$	7	4× 0.35=1.40	0.85× 2=1.70	3.10	3.90
$_8O$	$1s^2,2s^2,2p^4$	8	5× 0.35=1.75	0.85× 2=1.70	3.45	4.55
$_9F$	$1s^2,2s^2,2p^5$	9	6× 0.35=2.10	0.85× 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 σ = 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_{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 $Z_{eff} = Z - \sigma = 7 - 3.45 = 3.55$

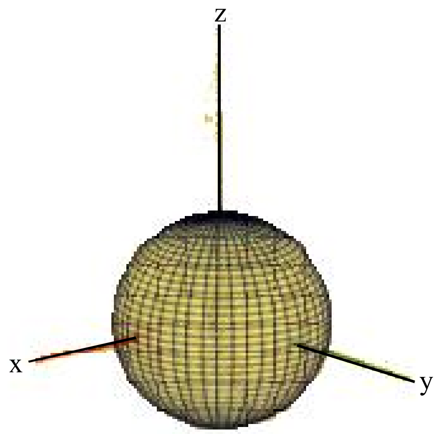
Electron configuration of N^+ = $(1s^2)\ (2s^2\ 2p^2)$

Shielding constant for the last 2p electron,

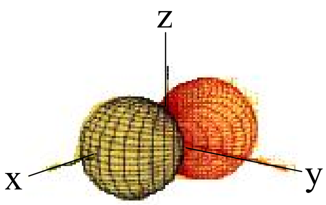
$\sigma = [(2 \times 0.85) + (3 \times 0.35)] = 2.75$

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

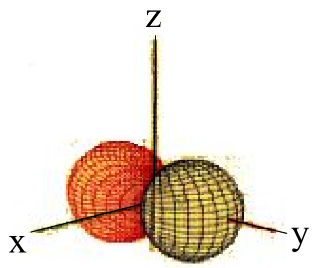
SHAPES OF ATOMIC ORBITALS



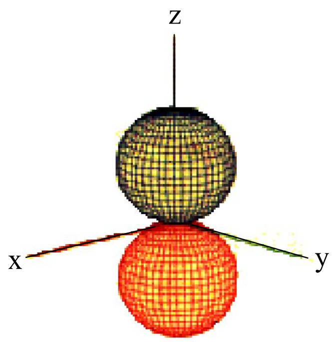
S



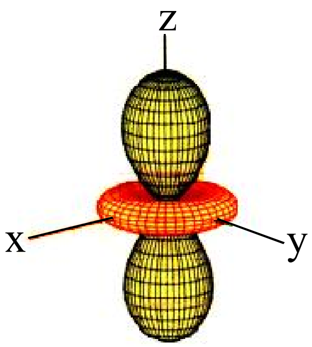
p_x



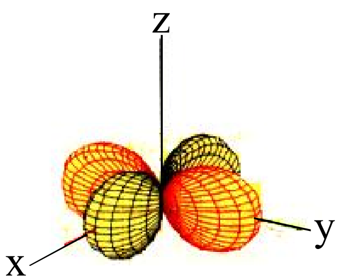
p_y



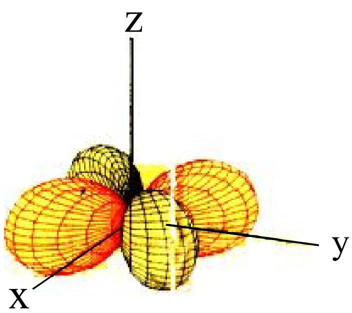
p_z



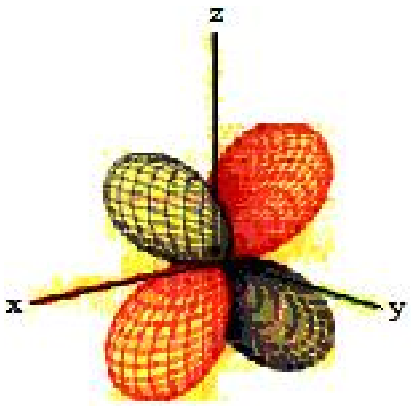
d_{z^2}



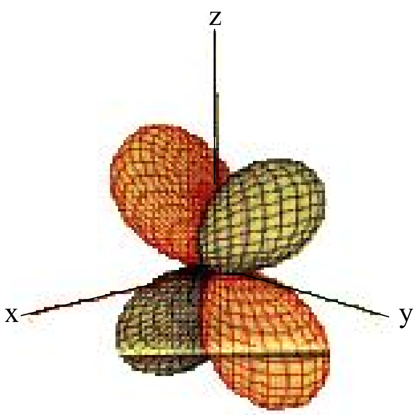
$d_{x^2-y^2}$



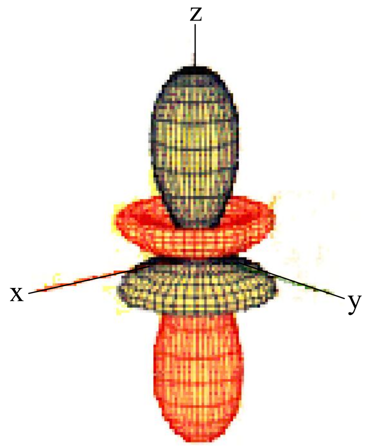
d_{xy}



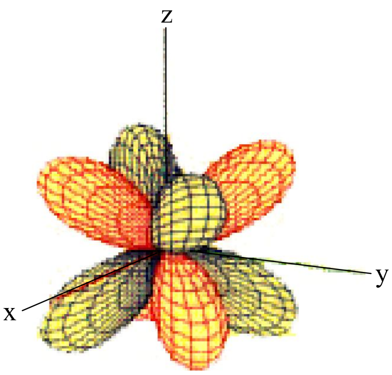
d_{xz}



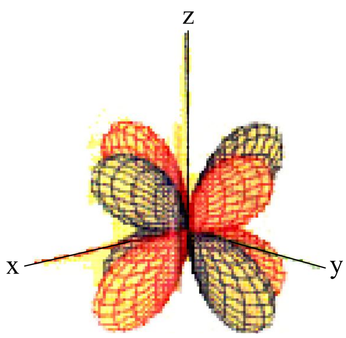
d_{yz}



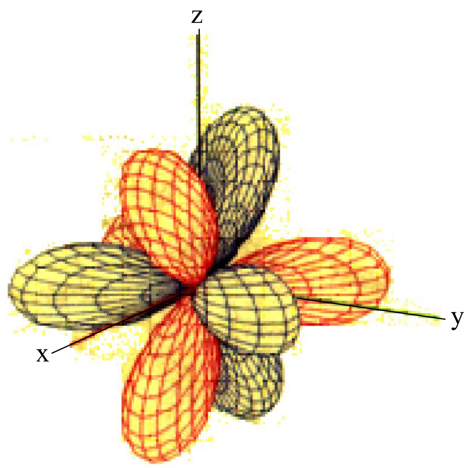
f_{z^3}



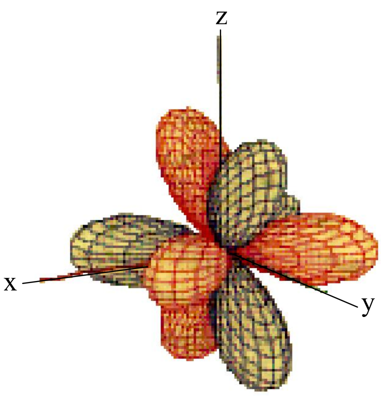
f_{xyz}



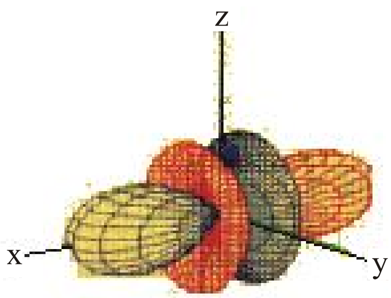
$f_{z(x^2-y^2)}$



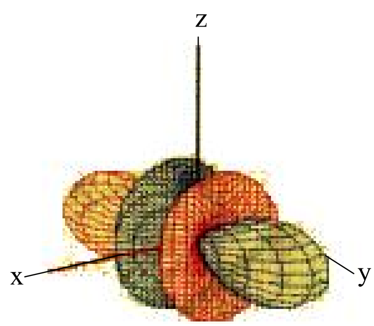
$f_{x(y^2-z^2)}$



$f_{y(z^2-x^2)}$



f_{x^3}



f_{y^3}

EXERCISE # O–1

General Introduction :

1. The total number of neutrons in dipositive zinc ion with mass number 70 is

(A) 34 (B) 40 (C) 36 (D) 38

QN0001

2. It is known that atom contain protons, neutrons and electrons. If the mass of neutron is assumed to half of its original value where as that of proton is assumed to be twice of its original value then the atomic mass of ${}^{14}_{6}C$ will be -

(A) same (B) 25% more (C) 14.28 % more (D) 28.5% less

QN0002

3. Two monoatomic cations $x^{\oplus}$ and y^{2+} are isoelectronic then select the correct statement : (Both elements are consecutive)

(A) Both element x and y have same number of electrons

(B) Total number of valence electrons are more in element x, than element 'y'

(C) Total number of valence electrons are more in element y, than element 'x'

(D) Both (A) and (B) are correct

QN0003

4. Which of the following sets contain only isoelectronic ions?

(A) Zn^{2+}, Ca^{2+}, Ga^{3+} , Al^{3+} (B) K^{+}, Ca^{2+}, Sc^{3+}, Cl^{-}

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

QN0004

Quantum number

5. Which quantum number will determine the shape of the orbital

(A) Principal quantum number (B) Azimuthal quantum number

(C) Magnetic quantum number (D) Spin quantum number

QN0005

6. In Palladium (Atomic no.–46), number of electron having ($\ell = 2$) will be -

(A) 20 (B) 18 (C) 16 (D) 22

QN0006

7. For an electron present in which of the following orbital for which $(n + l + m + s)$ value is maximum. Consider maximum possible value for 'm' and minimum possible value of m_s (where ever applicable).

(A) 3p (B) 5p (C) 4d (D) 5s

QN0007

8. Choose the correct option for the quantum numbers of the last electron of K^{+}.

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

QN0008

9. Find the sum of maximum number of electrons having +1 and –1 value of 'm' in Ti (Atomic number = 22)

(A) 6 (B) 8 (C) 10 (D) 12

QN0009

10. The number of electrons in Ca having minimum value of $\left|\frac{n}{\ell \times m_\ell}\right|$ is.

(Consider only non-zero values of ℓ and m)

(A) 6 (B) 3 (C) 4 (D) None of these

QN0010

Electronic Configuration

11. A neutral atom of an element has two K, eight L, nine M and two N electrons then electronic configuration of the element is

(A) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^2\ 4s^1$
(B) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^1\ 4s^2$
(C) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3d^2\ 3p^6\ 4s^1$
(D) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^2$

QN0011

12. 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

13. If the nitrogen atom had electronic configuration $1s^7$, it would have energy lower than that of normal ground state configuration $1s^2\ 2s^2\ 2p^3$, because the electrons would be closer to the nucleus. Yet $1s^7$ is not observed because it violates :–

(A) Uncertainity principle
(B) Hund's rule
(C) Pauli's exclusion principle
(D) Bohr postulate of stationary orbits

QN0013

Effective Nuclear charge (Z_{eff}) :

14. The Z_{eff} for (as Slater's rule)

3d electron of Cr

4s electron of Cr

3d electron of Cr^{3+}

3s electron of Cr^{3+} are in the order respectively

(A) 4.6, 2.95, 4.95, 8.05
(B) 4.95, 2.95, 4.6, 8.05
(C) 4.6, 2.95, 5.3, 12.75
(D) none of these

QN0014

15. Total number of possible shells in uranium atom (atomic no. z = 92)

(A) 7 (B) 1 (C) 6 (D) None of these

QN0015

16. Which of the following has the maximum number of unpaired electrons ?

(A) Mg^{2+} (B) Ti^{3+} (C) V^{3+} (D) Fe^{2+}

QN0016

17. Gaseous state electronic configuration of nitrogen atom can be represented as :

(A) $\uparrow\downarrow\ \uparrow\downarrow\ \uparrow\ \uparrow\ \uparrow$
(B) $\uparrow\downarrow\ \uparrow\downarrow\ \uparrow\ \downarrow\ \uparrow$
(C) $\uparrow\downarrow\ \uparrow\downarrow\ \uparrow\ \downarrow\ \downarrow$
(D) $\uparrow\downarrow\ \uparrow\downarrow\ \downarrow\ \downarrow\ \uparrow$

QN0017

EXERCISE # O-2

General Introduction :

1. Isotones are :

(A) The atoms of different elements

(B) Have same number of neutrons

(C) Have same number of (neutrons + protons)

(D) Have same difference of mass number and atomic number

QN0018

Quantum number

2. For an electron present in which of the following orbital for which (n + *l*) value is maximum.

(A) 3p (B) 5p (C) 4d (D) 5s

QN0019

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

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

QN0020

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

	n	ℓ	m		n	ℓ	m
(A)	2	1	0	(B)	2	1	1
(C)	3	1	1	(D)	3	1	0

QN0021

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

	n	ℓ	m	m_s		n	ℓ	m	m_s
(A)	3	3	–2	$\frac{1}{2}$	(B)	4	0	0	$\frac{1}{2}$
(C)	3	2	–3	$\frac{1}{2}$	(D)	5	3	0	$\frac{1}{2}$

QN0022

6. The quantum numbers for the 19th electron of Cr (Z = 24) are

(A) n = 3, ℓ = 0, m = 0, m_s = + ½ (B) n = 4, ℓ = 0, m = 0, m_s = + ½

(C) n = 3, ℓ = 2, m = 2, m_s = + ½ (D) n = 4, ℓ = 0, m = 0, m_s = – ½

QN0023

7. The maximum number of electron having $n \times \ell \times m = 0$ in Zn^{2+} is equal to the -

(A) Atomic number of Mg

(B) 12

(C) Total number of electron in Zn which have $n + \ell = 0$

(D) 'p' electrons in Ar

QN0024

Electronic Configuration

8. The species which have same number of electrons in outer most and penultimate shell -

(A) Ca (B) Ar (C) V^{+3} (D) Sc^{3+}

QN0025

9. Which sub-shell fill completely before the 4f?

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

QN0026

10. The electronic configuration of a carbon atom is $1s^2, 2s^2, 2p^2$ and consider the following four arrangements of the 2p electrons. Which arrangement have lowest energy ?

(A) [↑↓][ ][ ] (B) [↑][↓][ ] (C) [↑][↑][ ] (D) [↑][ ][↑]

QN0027

11. Hund's rule is applicable for :-

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

QN0028

12. Which of the following has maximum number of unpaired electron.

(A) Fe (B) Fe (II) (C) Fe (III) (D) Mn (II)

QN0029

13. Mn (Z = 25) = $1s^3\ 1p^9\ 2s^3\ 2p^9\ 2d^1$

Which of the following change is required so that Mn have above ground state electronic configuration :

(A) Change in the value of ℓ (azimuthal quantum number) for any subshell

(B) Change in the possible values of ℓ (azimuthal quantum number)

(C) Change in the Pauli rule

(D) Change in the $(n + \ell)$ rule

QN0030

14. 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}

QN0031

15. Select incorrect statement(s) :

(A) d_{z^2} orbital has different shape from rest of all d-orbitals

(B) For the formation of cation electrons are always removed from 4s.

(C) Zinc is a p-block element.

(D) Principal quantum number depend upon the value of azimuthal quantum number

QN0032

EXERCISE # S–1

Integer Answer Type (0 to 9) :

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

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

QN0033

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

QN0034

3. How many elements are possible for the Ist period of periodic table if azimuthal quantum number can have integral values from 0 to (n + 1). [n = shell number & other rules are remaning same to form periodic table.

QN0035

4. Find number of unpaired electrons when Fe does not follow $(n + \ell)$ rule and filling of electron takes palce shell after shell and Hund's rule is also not obeyed.

QN0036

5. Find the maximum number of electrons having same Z_{eff} value for sulphur atom

QN0037

6. Find the sum of maximum unpaired e^- present in one 5g & one 6g orbital.

QN0038

7. Find out the maximum number of electrons that can involve in the shielding of an electron, having quantum numbers : $n = 2, \ell = 1, m = 0, m_s = +\frac{1}{2}$, in an atom.

QN0039

8. Find the sum of minimum and maximum possible value of x in Fe^{+x} ion, if magnetic moment of $Fe^{+x} = 4.89$ B.M.

QN0040

EXERCISE # S–2

Paragraph for Question 1 to 3

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

1. The number of protons present in the divalent cation of the element of above configuration is :-

(A) 24 (B) 25 (C) 26 (D) 27

QN0041

2. The element is :

(A) Mn (B) Fe (C) Co (D) Li

QN0041

3. The number of unpaired electrons in the divalent cation of the given element in isolated gaseous state is :-

(A) 0 (B) 3 (C) 4 (D) 1

QN0041

Paragraph for Question 4 & 5

Consider a hypothetical atom where p_x, p_y, p_z, d_{xy}, d_{xz}, d_{yz} and $d_{x^2-y^2}$ orbitals are present for principal quantum number n = 4.

4. Find the number of other orbital which lobes are fully present in the nodal plane of p_x orbital :-

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

QN0042

5. Which of the following orbitals lobe is not present at all either in the nodal plane of p_x orbital or in the nodal plane of p_y orbital.

(A) d_{xy} (B) d_{yz} (C) $d_{x^2-y^2}$ (D) p_z

QN0042

Paragraph for Question 6 & 7

Isotopes, Isobars and Iso-diaphers are some basic definitions related to the atom, which are based upon the variation in no. of electron, proton or neutrons.

6. Which of the following pair represents the Isobar species :-

(A) ${}_{18}Ar^{40}$, ${}_{6}C^{12}$ (B) ${}_{8}O^{16}$, ${}_{7}N^{14}$ (C) N_2O, CO_2 (D) None of these

QN0043

7. Which of the following pair is correct for isosters :-

(A) N_2O, CH_4 (B) N_2O, CO_2 (C) CO_2, SO_2 (D) N_2O, HOCl

QN0043

8.

Column-I **Element**	**Column-II** **Max. value of n and ℓ respectively ; consider filled subshell only**
(P) P	(1) 6, 2
(Q) N	(2) 3, 1
(R) Pb	(3) 6, 3
(S) Cs	(4) 2, 1

Code :

	P	**Q**	**R**	**S**		**P**	**Q**	**R**	**S**
(A)	4	1	2	3	(B)	2	4	1	3
(C)	3	1	2	4	(D)	2	4	3	1

QN0044

9. Match the following:

Column–I	Column–II
(P) Same number of unpaired electrons are present in (excluding zero)	(1) Na^+, Mg^{2+}, F^-
(Q) Same number of electrons in s & p subshells.	(2) F^-, Mg, O^{2-}
(R) Same number of electrons with the l = 1	(3) Mg, Ne, O^{2-}
(S) Same number of total electrons	(4) Li, Na, K

Code :

	P	Q	R	S
(A)	1, 2	3, 4	1	4
(B)	4, 2	3, 1	2, 3	4, 1
(C)	4	1	1, 2, 3	1
(D)	3	1, 2	3, 4	1, 3, 4

QN0045

10. Match the following :

Column–I (Orbital)	Column–II (Property)
(P) s	(1) Have electron density at all three axes
(Q) p_x	(2) YZ plane is nodal plane
(R) d_{xy}	(3) dumbell shape
(S) $d_{x^2-y^2}$	(4) have azimuthal quantum no. $\ell = 2$

Code :

	P	Q	R	S
(A)	1, 3	2, 3	3	3, 4
(B)	1	2, 3	2, 4	4
(C)	1	2, 3, 4	3, 4	1, 4
(D)	2	3, 4	2, 3	1, 4

QN0046

Match The Column :

11. Match the following :

Column–I (e^- configuration)	Column–II (Property)
(A) d^8	(P) Symmetrical distribution
(B) d^{10}	(Q) Unsymmetrical distribution
(C) d^6	(R) No of exchange pair are maximum among these
(D) d^5	(S) two electrons must be present in $d_{x^2-y^2}$ orbital
	(T) at least one electron is present in orbital having m = –1

QN0047

12. **Column-I** **Column-II**

Column-I	Column-II
(A) Zn^{2+}	(P) Diamagnetic
(B) Ga^{+}	(Q) Spin magnetic moment = $\sqrt{35}$ BM
(C) Fe^{3+}	(R) 18 e^{-} in outer most shell
(D) Br^{-}	(S) 3d subshell is fully filled
	(T) All the orbital of outer most shell are fully filled

QN0048

MATCHING LIST TYPE 1 × 3 Q. (THREE LIST TYPE Q.)

Column - I	Column - II	Column - III
(A) Paramagnetic set	(i) Na^{+},Mg^{+2}, F^{-}	(P) same value of principal quantum number for last electron
(B) Isoelectronic set	(ii) Li, Na, K	(Q) The non zero number(s) of e^{-}(s) for n = 3 and $\ell \geq 1$ is
(C) The set for which value(s) of spin multiplicity is ≥ 1	(iii) Fe^{+3}, Co^{2+}, Ni^{+2}	(R) The value of "m_s" must be $+\frac{1}{2}$ for last electron
(D) The set of elements belongs to same period in periodic table	(iv) S^{-2}, Cl^{-}, P^{-3}	(S) Set for which the value of m = ±2 is possible for electron(s)

13. Which one of the following options is the **CORRECT** combination?

(A) (A, i, P) (B) (B, iv, S) (C) (D, iii, S) (D) (C, iii, R)

QN0049

14. Which one of the following options is the **INCORRECT** combination?

(A) (A, iii, P) (B) (C, ii, P) (C) (B, i, P) (D) (B, iv, Q)

QN0049

15. Which one of the following options is the **CORRECT** set of species with number of nodal planes for filled/partially filled orbitals is $\leq$ 1 for all given species in set?

(A) (B, ii, R) (B) (B, iv, P) (C) (A, i, Q) (D) (D, iii, S)

QN0049

EXERCISE # JEE-MAIN

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

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

(a) n = 4 , ℓ = 1 (b) n = 4, ℓ = 0 (c) n = 3, ℓ = 2 (d) n = 3, ℓ = 1

Can be placed in order of increasing energy as

(1) (a) < (c) < (b) < (d) (2) (c) < (d) < (b) < (a)

(3) (d) < (b) < (c) < (a) (4) (b) < (d) < (a) < (c)

QN0050

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

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

(1) V^{2+} (2) Ti^{2+} (3) Mn^{2+} (4) Cr^{2+}

QN0051

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]**

(1) 1 (2) 5 (3) 3 (4) 7

QN0052

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

[JEE-MAIN, (ONLINE)-2013]

(1) 10, 10, 10 (2) 8, 10, 11

(3) 10, 11, 10 (4) 11, 10, 10

QN0053

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

(a) n=5, m_l = +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

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

[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

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

[JEE-MAIN, (ONLINE)-2015]

(1) ns→(n–1)d→(n–2)*f*→np (2) ns→np→(n–1)d→(n–2)*f*

(3) ns→(n–2)*f*→(n–1)d→np (4) ns→(n–2)*f*→np→(n–1)d

QN0056

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

[JEE-MAIN, (ONLINE)-2016]

(1) 25 (2) 5 (3) 20 (4) 10

QN0057

9. The group having isoelectronic species is :- **[JEE-MAIN 2017]**

(1) O^{2-} , F^{-} , Na^{+} , Mg^{2+}
(2) O^{-} , F^{-} , Na , Mg^{+}
(3) O^{2-} , F^{-} , Na , Mg^{2+}
(4) O^{-} , F^{-} , Na^{+} , Mg^{2+}

QN0058

10. The isotopes of hydrogen are : **[JEE-MAIN ONLINE 2019]**

(1) Tritium and protium only

(2) Deuterium and tritium only

(3) Protium and deuterum only

(4) Protium, deuterium and tritium

QN0059

11. The quantum number of four electrons are given below - **[JEE-MAIN ONLINE 2019]**

I. $n = 4, l = 2, m_l = -2, m_s = -½$

II. $n = 3, l = 2, m_l = 1, m_s = +½$

III. $n = 4, l = 1, m_l = 0, m_s = +½$

IV. $n = 3, l = 1, m_l = 1, m_s = -½$

The correct order of their increasing energies will be -

(1) IV < III < II < I
(2) IV < II < III < I
(3) I < II < III < IV
(4) I < III < II < IV

QN0060

12. The isoelectronic set of ions is : **[JEE-MAIN ONLINE 2019]**

(1) N^{3-}, Li^{+}, Mg^{2+} and O^{2-}
(2) Li^{+}, Na^{+}, O^{2-} and F^{-}
(3) F^{-}, Li^{+}, Na^{+} and Mg^{2+}
(4) N^{3-}, O^{2-}, F^{-} and Na^{+}

QN0061

13. The number of orbitals associated with quantum numbers $n = 5, m_s = +\frac{1}{2}$ is :

[JEE-MAIN ONLINE 2020]

(1) 11 (2) 25 (3) 15 (4) 50

QN0062

14. Hydrogen has three isotopes (A), (B) and (C). If the number of neutron(s) in (A), (B) and (C) respectively, are (x), (y) and (z), the sum of (x), (y) an (z) is : **[JEE-MAIN ONLINE 2020]**

(1) 4 (2) 3 (3) 2 (4) 1

QN0063

EXERCISE # JEE-ADVANCED

1. 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

2. 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

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

QN0066

ANSEWR KEY

EXERCISE # O–1

Que.	1	2	3	4	5	6	7	8	9	10
Ans.	B	C	C	B	B	A	C	B	C	C
Que.	11	12	13	14	15	16	17			
Ans.	B	B	C	C	D	D	A			

EXERCISE # O–2

Que.	1	2	3	4	5	6	7	8	9	10
Ans.	A, B, D	B, C	A, B	C, D	A, C	B, D	A, B, D	B, D	A, B, D	C, D
Que.	11	12	13	14	15					
Ans.	A, B, D	C, D	B, C, D	B, C	B, C, D					

EXERCISE # S–1

Que.	1	2	3	4	5	6	7	8		
Ans.	4	9	8	0	8	2	9	6		

EXERCISE # S–2

Que.	1	2	3	4	5	6	7	8	9	10
Ans.	C	B	C	C	A	D	B	D	C	B
Que.	11					12				
Ans.	(A)-Q,T (B)-P,R,S,T (C)-Q,T (D)-P,T					(A)-P,R,S,T (B)-P,S (C)-Q (D)-P,S				
Que.	13	14	15							
Ans.	C	B	B							

EXERCISE # JEE-MAIN

Que.	1	2	3	4	5	6	7	8	9	10
Ans.	3	3	1	1	1	3	3	1	1	4
Que.	11	12	13	14						
Ans.	2	4	2	2						

EXERCISE # JEE-ADVANCED

Que.	1	2	3		
Ans.	9	6	3		