Chapter - 3

Periodic Table and Electron Configuration

- ✓ **Louis de Broglie** discovered the **wave natur**e of **matter**. This wave nature is highly significant for microscopic particles.
- ✓ According to **Heisenberg's Uncertainty Principle**, it is impossible to determine simultaneously the exact position and the exact velocity of a fast moving subatomic particle like electron.
- ✓ on the basis of wave - particle dual nature and uncertainty principle an electron cannot be considered merely as a particle moving along an orbit. This is considered as one of the limitations of Bohr atom model.

Quantum Mechanical Model of Atom

- ✓ An atom model that is in line with the dual nature of matter and the uncertainty principle was developed on the basis of quantum mechanics.
- ✓ According to quantum mechanical model of atom, there are regions around the nucleus where there is maximum probability of finding the electrons.

Orbital

- ✓ The regions around the nucleus where there is maximum probability of finding the electrons are called orbitals.

Quantum Numbers

- ✓ The numbers which are used to describe the characteristics of orbitals and electrons based on quantum mechanical model of atom are called quantum numbers.
- ✓ Principal quantum number, Azimuthal quantum number and magnetic quantum number are examples of quantum numbers.

Principal Quantum number (n)

- ✓ Principal quantum number (n) is used to represent the shells or principal energy levels.
- ✓ The possible values for this quantum number are n = 1, 2, 3, 4, ...

n = 1 denotes K shell
n = 2 denotes L shell.
n = 3 denotes M shell.
n = 4 denotes N shell.

Principal quantum number (n)	1	2	3	4
Shell	K	L	M	N

Azimuthal Quantum Number (l)

- ✓ Azimuthal quantum number (l) defines the three dimensional **shape of the orbital**.
- ✓ The orbitals having definite three dimensional shape and oriented towards different directions are clubbed together and considered as **subshells**.
- ✓ Azimuthal quantum number is also used to represent the subshells of each shell.
- ✓ The subshells are denoted using the symbols s, p, d and f.
  $l = 0$ denotes s subshell
  $l = 1$ denotes p subshell.
  $l = 2$ denotes d subshell
  $l = 3$ denotes f subshell.

Azimuthal quantum number (l)	0	1	2	3
Subshell	s	p	d	f

- ✓ The value of l can be determined from the value of n.
- ✓ The value of l ranges from zero to (n-1).
- ✓ The number of subshells in a particular shell is equal to the values of n.

Principal quantum number (n)	1	2		3			4			
Shell	K	L		M			N			
l	0	0	1	0	1	2	0	1	2	3
Subshell	s	s	p	s	p	d	s	p	d	f
Number of subshells	1	2		3			4			

n	l	Subshell notation
4	0	$2s$
5	2	$5d$
4	3	$4f$
3	1	$3p$

Magnetic Quantum Number (m)

- ✓ The quantum number that represents the difference in the orientation of orbitals is called magnetic quantum number.
- ✓ Magnetic quantum number is denoted using the symbol ‘m’.
- ✓ For a particular value of l, there are $(2l + 1)$ values for m.

Principal quantum number (n)	1	2		3			4			
Shell	K	L		M			N			
l	0	0	1	0	1	2	0	1	2	3
Subshell	s	s	p	s	p	d	s	p	d	f
Number of orientations or orbitals	1	1	3	1	3	5	1	3	5	7
Total number of orientations or orbitals	1	4		9			16			

- ✓ The **maximum number of electrons** that can be accommodated in **each orbital** is **2**.

Subshell	Number of orbitals	Maximum number of electrons that can be accomodated
s	1	$1 \times 2 = 2$
p	3	$3 \times 2 = 6$
d	5	$5 \times 2 = 10$
f	7	$7 \times 2 = 14$

Shell	Number of orbitals	Maximum number of electrons that can be accomodated
K	1	$1 \times 2 = 2$
L	4	$4 \times 2 = 8$
M	9	$9 \times 2 = 18$
N	16	$16 \times 2 = 32$

The maximum number of orbitals that can be accomodated in each shell $= n^2$

The maximum number of electrons that can be accomodated in each orbital $= 2$

The maximum number of electrons that can be accomodated in each shell $= 2n^2$

The maximum number of orbitals that can be accomodated in each subshell $= 2l + 1$

The maximum number of electrons that can be accomodated in each subshell $= 2(2l + 1)$

The maximum number of electrons that can be accomodated in s subshell $= 2$

The maximum number of electrons that can be accomodated in p subshell $= 6$

The maximum number of electrons that can be accomodated in d subshell $= 10$

The maximum number of electrons that can be accomodated in f subshell $= 14$

Filling of electrons in subshells

- ✓ The energy of shells increases in the order

$$K < L < M < N.$$

- ✓ The energy of subshells increases in the following order.

$$s < p < d < f$$

- ✓ The energy of subshells increases in the ascending order of $(n + l)$ values. Where n and l are principal quantum number and azimuthal quantum number respectively.

Eg : $3d$ $4s$

$n = 3$ $n = 4$

$l = 2$ $l = 0$

$n + l = 5$ $n + l = 4$

Hence $3d$ subshell has more energy than $4s$ subshell.

- ✓ If two orbitals have the same $n + l$ value, the orbital with a highier n value has highier energy.

Eg : $2p$ $3s$

$n = 2$ $n = 3$

$l = 1$ $l = 0$

$n + l = 3$ $n + l = 3$

Here $n + l$ value of both the subshells are same, but the subshell $3s$ has highier n value than $2p$. Hence $3s$ subshell has more energy than $2p$ subshell.

The increasing order of energies of orbitals is as follows:

$$1s < 2s < 2p < 3s < 3p < 4s < 3d \ldots\ldots$$

Electron Configuration

- ✓ When the electrons in an atom are distributed in subshells, they are being filled gradually in the increasing order of energies of the subshells. This is called subshell electron configuration.

Atomic number (Z)	**Subshell electron configuration**
1	$1s^1$
2	$1s^2$
3	$1s^2\ 2s^1$
8	$1s^2 2s^2 2p^4$
10	$1s^2 2s^2 2p^6$
11	$1s^2 2s^2 2p^6 3s^1$
13	$1s^2 2s^2 2p^6 3s^2 3p^1$
17	$1s^2 2s^2 2p^6 3s^2 3p^5$
18	$1s^2 2s^2 2p^6 3s^2 3p^6$
20	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$
21	$1s^2 2s^2 2p^6 3s^2 3p^6\ 3d^1\ 4s^2$
25	$1s^2 2s^2 2p^6 3s^2 3p^6\ 3d^5\ 4s^2$
30	$1s^2 2s^2 2p^6 3s^2 3p^6\ 3d^{10}\ 4s^2$

- ✓ While writing the electron configuration of an element, the symbol of the noble gas preceding that element is shown within square bracket followed by the electron configuration of the remaining subshell.

Examples

- Atomic number = 5

Electronic configuration is $[He]2s^2 2p^1$

- Atomic number = 11

Electronic configuration is $[Ne]3s^1$

- Atomic number $= 19$

Electronic configuration is $[Ar]4s^1$

- Atomic number $= 28$
  Electronic configuration is $[Ar]3d^8 4s^2$

Special Case : Electronic configuration of **Chromium** $\left({}_{24}\boldsymbol{Cr}\right)$ and **Copper** $\left({}_{29}\boldsymbol{Cu}\right)$

${}_{24}\boldsymbol{Cr} = 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ \boldsymbol{3d^5\ 4s^1} = [Ar]\boldsymbol{3d^5 4s^1}$
${}_{29}\boldsymbol{Cu} = 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ \boldsymbol{3d^{10}\ 4s^1} = [Ar]\boldsymbol{3d^{10} 4s^1}$

Reason : For the subshell electronic configuration of chromium and copper, the configurations with half filled d subshell (Chromium) or completely filled d subshell (Copper) show greater stability.

Block, and Period number of an element from electron configuration

- ✓ The subshell to which the **last electron** is added will be the same as the **block** to which the electron belongs.
- ✓ The **period number** of an element is the **highest shell number** in its subshell electron configuration.

Example

$${}_{16}O = 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$$

The block to which O belongs $= p$ block

Period number of O $= 3$

Block and Group number of an element

S block

Group number $=$ number of electrons in the outermost **s** sub shell

Example

$${}_{12}Mg = 1s^2\ 2s^2\ 2p^6\ 3s^2$$

The block to which Mg belongs $= s$ block

Number of electrons in the outermost s subshell $= 2$

Group number $= 2$

p block

$$Group\ number = \boldsymbol{p+12}$$

$p =$ number of electrons in the outermost p subshell

Example

$$_{15}P = 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^3$$

The block to which P belongs $= p$ block

Number of electrons in the outermost p subshell $= 3$

Group number $= 3 + 12 = 15$

d block

$$Group\ number = \boldsymbol{s+d}$$

$s =$ number of electrons in the outermost s subshell

$d =$ number of electrons in the penultimate d subshell

Example

$$_{26}Fe = 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6 3d^6 4s^2$$

The block to which P belongs $= d$ block

Number of electrons in the outermost s subshell $= 2$

Number of electrons in the penultimate d subshell $= 6$

Group number $= 2 + 6 = 8$

Periodic trend in periodic table

Ionisation enthalpy

- ✓ Ionisation enthalpy of an element is the minimum amount of energy required to remove the most loosely bound electron from the outermost shell of an isolated gaseous atom of the element.
- ✓ On moving down a group,

i. number of shells increases

ii. size increases

iii. attractive force of the nucleus on the outermost electron increases

iv. Hence ionisation enthalpy decreases

- ✓ On moving from left to right along a period,

i. nuclear charge increases

ii. size decreases

iii. attractive force of the nucleus on the outermost electron increases

iv. Hence ionisation enthalpy increases.

Characteristics of s block elements

- These are elements in which the last electron enters in the outer most s sub shell.
- They include elements of the groups 1 & 2
- They are all reactive elements
- Less ionisation enthalpy
- First group elements are called alkali metals
- Second group elements are called alkaline earth metals
- The elements of group 1 and group 2 exhibit +1 and +2 oxidation states respectively.
- s block elements generally exist in solid state.
- Caesium $\left({}_{55}Cs\right)$ is a metal having very low melting point. Hence it exists in liquid state on warm days.
- The elements Francium $\left({}_{87}Fr\right)$ and Radium $\left({}_{88}Ra\right)$ are radioactive in nature.

Characteristics of p block elements

- These are elements in which the last electron enters in the outer most p sub shell.
- They include elements of the groups 13 to 18
- Show highier ionisation energy than the s block elements
- Includes metals, non metals, metalloids and noble gases
- Includes gas, liquid and solid state elements.
- Gallium is an element having a very low melting point. On warm days, it exist in the liquid state.
- P block elements show both positive and negative oxidation states.

Characteristics of d block elements

- These are elements in which the last electron enters in the penultimate d sub shell.
- They include elements of the groups 3 to 12.
- d block elements are known as transition elements.
- They are all metals
- They show variable oxidation state
- They show similarities in properties not only within the groups but also along the periods.
- They form coloured compounds
- The presence of ions of transition elements (Cu^{2+}, Co^{2+}) or the ions which contain transition elements $(MnO_4^-,\ Cr_2O_7^{2-})$ are generally responsible for the colour of the compounds.
- the compounds of zinc (Zn) are colourless.

Q. **Why transition (d block) elements show variable oxidation state**?

Answer : In the case of transition elements the difference in energy between the outermost s subshell and the penultimate d subshell is very small. Hence under suitable conditions the electrons in d subshell also take part in chemical reactions. Hence they show variable oxidation state.

Q. Transition elements show similarities in properties not only within the groups but also along the periods. Why?

Answer : The electron configuration of the outermost subshell of d block elements along a period is generally the same.

Characteristics of f block elements

- These are elements in which the last electron enters in the anti-penultimate f sub shell.
- They include lanthanides of 6^{th} period and actinides of 7^{th} period.
- They are also called Inner trasition elements.
- They show variable oxidation state.
- Actinoids are radioactive elements. These include man-made elements as well.
- Used as fuels in nuclear reactors (Eg: isotopes of elements Uranium, Thorium, Plutonium)

- Neodymium (Nd) is used for making strong magnets.
- Some elements (Eg: Cerium (Ce), Lanthanum (La)) used as catalysts in the petroleum industry.

Rare earth elements

- ✓ Rare earth elements consist of 17 elements including 15 elements of Lanthanoids along with scandium and yttrium.
- ✓ Since they lie scattered on the earth's surface, it is difficult to find them in large quantities in a particular region. Hence, the process of extracting the metal from its ore is often a challenging task.
- ✓ They are used in computers, LCD screens, mobile phones, renewable energy sources, batteries,
- ✓ Monazite, one of the main ores of rare earth metals, is commonly found in the coastal regions of southern Kerala.

Subshell electronic configuration of ions

Compounds	Oxidation state of Mn	Subshell electron configuration of Mn ion
$MnCl_2$	$+2$	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^5$
MnO_2	$+4$	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^3$
Mn_2O_3	$+3$	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^4$
Mn_2O_7	$+7$	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$

Compounds	Oxidation state of Fe	Subshell electron configuration of Fe ion
$FeCl_2$	$+2$	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^6$
$FeCl_3$	$+3$	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^5$

Let us assess

1. The element X having 3 shells belongs to group 17.

a. Write the subshell electron configuration of this element.

b. To which block does this element belong?

c. What is its period number?

d. Write the molecular formula of the compound formed when X reacts with an atom of element Y which belongs to the third period and has one electron in its p subshell.

2. A few subshells are given.

$3p, 4d, 3f, 2d, 2p$

a. Among these, which subshells are not possible?

b. Explain the reason.

3. The position of two elements A and B in the periodic table are given. (Symbols are not real)

A - 4th period and 2nd group

B - 2nd period and 16th group

a. Write the subshell electron configuration of A and B.

b. Write the values of n and l of electrons in the outermost subshell of A.

c. How many orbitals are there in the subshell of B having the outermost electron? Find it on the basis of magnetic quantum number 'm'.

d. Write the molecular formula of the compound formed by the combination of A and B.

e. What type of chemical bond is present in this compound?

4. The subshell electron configuration of a few elements are written on the basis of noble gas.

(i) $[Ne]\ 3s^2\ 3p^6$ (ii) $[He]\ 2s^1$

(iii) $[Ar]\ 3d^2 4s^2$ (iv) $[Kr]\ 5s^2$

a. Write the complete subshell electron configuration.

b. Find the symbols of these elements with the help of periodic table.

5. The last electron of an atom is added to the 3d subshell. There are 7 electrons in this subshell.

Answer the following questions regarding this atom.

a. What is its atomic number?

b. Write its complete electron configuration.

c. To which block does it belong?

d. Find its period number.

e. What is its group number?

6. Find the oxidation state of s block elements in the following compounds..

a. Na_2O b. KBr c. CaO d. $MgCl_2$

7. Which subshell is represented by each pair of the quantum number values given below?

a. $n = 1, l = 0$ b. $n = 2, l = 1$

8. A few subshells are given. Find the values of n and l.

a. 2s b. 4p c. 3d d. 5f

9. The subshell electron configuration of certain elements are given. Write the short form of each using the symbol of corresponding inert gas.

a. $1s^2 2s^2 2p^4$

b. $1s^2 2s^2 2p^6 3s^2 3p^5$

c. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$

d. $1s^2 2s^2 2p^6 3s^2 3p^6\ 3d^5\ 4s^2$

10. Iron (Fe) takes part in chemical reactions and becomes Fe^{3+} ion. (Atomic number of Fe = 26).

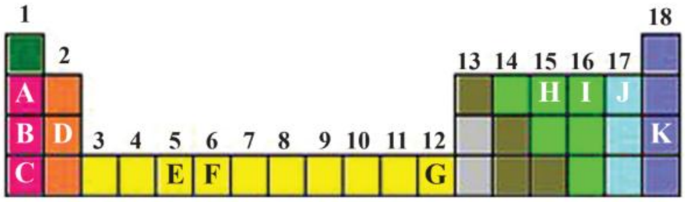
a. Write the electron configuration of this ion.

b. Write the chemical formula of the compound formed when this ion combines with sulphate ion (SO_4^{2-}) .

c. Which is the other oxidation state of this element? Write the electron configuration of the ion thus formed.

d. Iron shows variable oxidation states. Why?

11. A portion of the periodic table is given. Answer the following questions (Symbols are not real).



a. Which element has the lowest ionisation enthalpy?

b. Identify the alkaline earth metal.

c. Which are the d block elements?

d. Which element has the completely filled d subshell?

e. Identify the element having the electron configuration $3d^3 4s^2$?

f. Identify the noble gas.

g. Which element has only 3 electrons in the outermost p subshell?

<u>Answers</u>

1. a. $1s^2 2s^2 2p^6 3s^2 3p^5$

b. p block

c. 3

d. Group number of $X = 17$

Valency of $X = 1$

Group number of $Y = 13$

Valency of $Y = 3$

Molecular formula of the compound $= YX_3$

2. a. $3f, 2d$

b. The subshell 'd' requires an azimuthal quantum number $l = 2$, but in second shell $(n = 2)$ the possible values of l are 0 and 1. Hence $2d$ is not possible.

Similarly, The subshell 'f' requires an azimuthal quantum number $l = 3$, but in third shell $(n = 3)$ the possible values of l are 0,1 and 2. Hence $3f$ is not possible.

3. a. $A - 1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$

$B - 1s^2 2s^2 2p^4$

b. Outermost subshell of A $= 3s$

$n = 3,\ l = 0$

c. Outermost subshell of B $= 2p$

Number of orbitals $= 3$

d. Group number of $A = 2$

Valency of $A = 2$

Group number of $B = 16$

Valency of $Y = 2$

Molecular formula of the compound $= AB$

e. Ionic bond

4. a.

(i) $1s^2 2s^2 2p^6 3s^2 3p^6$

(ii) $1s^2 2s^1$

(iii) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^2 4s^2$

(iv) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 5s^2$

b. (i) Ar (ii) Li (iii) Ti (iv) Sr

5. a. 27

b. $1s^2 2s^2 2p^6 3s^2 3p^6 3d^7 4s^2$

c. d block

d. 4

e. $7 + 2 = 9$

6. a. Na_2O

Oxidation state of $O = -2$

Take oxidation state of Na as x

$2 \times x - 2 = 0 \Longrightarrow \; 2x = 2 \; \Longrightarrow \; x = \frac{2}{2} = 1$

oxidation state of $Na = +1$

b. Oxidation state of $Br = -1$

Take oxidation state of K as x

$x - 1 = 0 \Longrightarrow \quad x = 1$

oxidation state of $K = +1$

c. Oxidation state of $O = -2$

Take oxidation state of Ca as x

$x - 2 = 0 \Longrightarrow \quad x = 2$

oxidation state of $Ca = +2$

d. Oxidation state of $Cl = -1$

Take oxidation state of Mg as x

$x + 2 \times -1 = 0 \Longrightarrow \quad x - 2 = 0 \quad \Longrightarrow \quad x = 2$

oxidation state of $Na = +2$

7. a. $1s$

b. $2p$

8. a. $n = 2, \; l = 0$

b. $n = 4, \quad l = 1$

c. $n = 3, \quad l = 2$

d. $n = 5, \quad l = 3$

9. a. $[He]2s^2 2p^4$

b. $[Ne]3s^2 3p^5$

c. $[Ar]\ 4s^1$

d. $[Ar]\ 3d^5 4s^2$

10. a. $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5$

b. Cation $(+ve\ ion) = Fe^{3+}$

Anion $(-ve\ ion) = SO_4^{2-}$

Chemical formula of the compound $= \boldsymbol{Fe_2(SO_4)_3}$

c. $+2$

$Fe^{2+} - 1s^2 2s^2 2p^6 3s^2 3p^6 3d^6$

d. The difference in energy between the outermost s subshell and the penultimate d subshell is very small.

11. a. C

b. D

c. E, F, G

d. G

e. E

f. K

g. H

Question Bank with Answers

1. Manganese (Mn) is an element that exhibits different oxidation states. (Atomic number of Mn – 25)

a. Find the oxidation state of Mn in MnO_2.

b. Write the subshell electron configuration of manganese ion in MnO_2.

2. The last two electrons of the element P belonging to the third period are filled in the s subshell. (The symbol is not real)

a. What is the atomic number of this element?

b. Write the chemical formula of the oxide of this element.

c. Write the subshell electron configuration of the element in the fourth period belonging to the same group.

3. The position of the two elements in the periodic table is given. (The symbols are not real)

Element P : Period – 2, Group – 16

Element Q : Period – 3, Group – 1

a. Write the n and l values of the outermost subshell of Q containing electrons.

b. How many orbitals will be present in the subshell containing the outermost electron of P?

c. Write the chemical formula of the compound formed by combining P and Q.

4. **Assertion (A)** : The $3s$ subshell has higher energy than the $2p$ subshell.

Reason (R) : The $(n + 1)$ value of $3s$ subshell is greater than that of $2p$ subshell.

Which among the following is **correct** ?

(a) (A) and (R) are true, (R) is the correct explanation of (A).

(b) (A) and (R) are true, but (R) is not the correct explanation of (A).

(c) (A) is true, (R) is false.

(d) (A) is false, (R) is true.

5. Element X of the third period of the periodic table has the lowest ionisation enthalpy. (Symbol is not real)

a. In which group does X belong?

b. What is its atomic number?

6. The chemical formulae of two oxides of manganese are given

(i) Mn_2O_3

(ii) MnO_2

(Hint : oxidation state of oxygen $= -2$, atomic number of manganese $= 25$)

a. In which compounds manganese shows $+4$ oxidation state?

b. Write the subshell electron configuration of Mn^{4+}.

c. Why do d – block elements show variable oxidation states?

7. **Assertion (A)** : The last electron of d block elements in 4th period are filled in penultimate shell.

Reason (R) : $3d$ has more energy than $4s$ subshell.

Which of the following is correct?

A. Both A and R are correct, R is not the correct explanation of A.

B. A is correct, but R is not correct.

C. Both A and R are correct and R is the correct explanation of A

D. Both A and R are not correct

8. Two statements regarding a particular block of elements are given below.

i. They are known as inner transition elements.

ii. Filling up of electrons takes place in anti penultimate shell.

a. Which is the block of elements described here?

b. Write any one characteristic property of the elements belong to this block.

9. The $(n + l)$ value of two orbitals is 5 each. One of the orbitals has 5 orientations and the other has 3 orientations.

a. Identify the orbitals.

b. Which of them has higher energy? Explain the reason.

10. Some information about two subshells are given below.

i. Shell name : M, number of orientations : 5

ii. Shell name : N, number of orientations : 1

a. Represent the given subshells.

b. Write the maximum number of electrons that can be accommodated in each of these.

11. The position of a metal M (Symbol not real) in the periodic table is given below.

Period : 4

Group : 11

a. Write the subshell electron configuration of M.

b. Write the subshell electron configuration of M^{+} and M^{2+}.

12. The subshell electron configuration of some elements are given. (Symbols are not real)

A – $1s^2 2s^2 2p^6 3s^2 3p^6$

B – $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5 4s^2$

C – $1s^2 2s^2 2p^6$

D – $1s^2 2s^2 2p^6 3s^2 3p^6 3d^8 4s^2$

a. Which of them belong to same period?

b. Write the group and period of B.

c. Select the element which belongs to the same group of A.

13. **Statement l** : L shell contains a maximum of 8 electrons.

Statement 2 : L shell has five orbitals.

Which of the following options is true regarding these statements?

A. Statements 1 and 2 arc correct.

B. Statement 1 is correct, but 2 is not correct.

C. Statement 1 is not correct, but 2 is correct.

D. Statements 1 and 2 arc not correct.

14. Two statements regarding a shell are given below

- The last electron of an atom fills into the shell with principal quantum number $n = 3$.
- This shell contains a total of seven electrons.

a. Write the electron configuration of this atom.

b. Write the names of subshells present in the shell with $n = 2$.

c. How many orientations will be there for subshell with $l = 1$?

15. The last electron in an atom has the following quantum numbers associated with it, $n = 2, l = 1$

a. Represent the given subshell.

b. Find the number of orientations possible for this given subshell.

c. What is the total number of orbitals in the shell with $n = 2$.

<u>Answers</u>

1. a. Oxidation state of $O = -2$

Take oxidation state of $Mn = x$

$x + 2 \times -2 = 0 \Longrightarrow \quad x - 4 = 0 \Longrightarrow \quad x = 4$

oxidation state of $Mn = 4$

b. Electron configuration of Mn^{4+} is

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

2. Period number of P $= 3$

Block of P $= s$ block

Group of P $= 2$

a. Atomic number $= 12$

b. Valency of $P = 2$

Valency of oxygen $(O) = -2$

Chemical formula of the oxide $= PO$

c. Period number $= 4$, Group number $= 2$

Electron configuration is $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$

3. a. Outermost subshell of $Q = 2p$

$n = 2, \quad l = 1$

b. Outermost subshell of $P = 3s$

Number of orbitals $= 1$

c. Valency of $P = 2$

Valency of $Q = 1$

Chemical formula $= QP_2$

4. $2p$: $n = 2$, $l = 1$ and $n + l = 3$

$3s$: $n = 3$, $l = 0$ and $n + l = 3$

$n + l$ value is same for both the orbitals. Hence R is false

(c) (A) is true, (R) is false.

5. a. Group number $= 1$

b. $1s^2 2s^2 2p^6 3s^1$

Atomic number $= 11$

6. Take oxidation state of $Mn = x$

In Mn_2O_3

$2x + 3 \times -2 = 0 \Longrightarrow 2x - 6 = 0 \Longrightarrow 2x = 6$

$x = \frac{6}{2} = 3$

oxidation state of Mn in $Mn_2O_3 = +3$

In MnO_2

$x + 2 \times -2 = 0 \Longrightarrow x - 4 = 0 \Longrightarrow x = 4$

oxidation state of Mn in $MnO_2 = +4$

a. MnO_2

b. $1s^2 2s^2 2p^6 3s^2 3p^6 3d^3$

c. The difference in energy between the outermost s subshell and the penultimate d subshell is very small.

7. C. Both A and R are correct and R is the correct explanation of A

8. a. f block

b. Show varable oxidation state

9. a. Orbital 1

Number of orientations = 5

Hence it is a **d** orbital $\implies \ l = 2$

$n + l = 5 \implies \ n = 5 - 2 = 3$

Orbital 2

Number of orientations = 3

Hence it is a **p** orbital $\implies \ l = 1$

$n + l = 5 \implies \ n = 5 - 1 = 1$

Orbital 1 = $3d$

Orbital 2 = $4p$

b. $n + l$ value of both the orbitals are same, but $4p$ has highier n value. Hence **$4p$ has highier energy**.

10. n value of M shell = 3

n value of N shell = 4

5 orientations represent d subshell

1 orientation represent s subshell

a. i. $3d$

ii. $4s$

b. i. 10

ii. 2

11. a. $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^1$

b. $M^+ - 1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10}$

$M^{2+} - 1s^2 2s^2 2p^6 3s^2 3p^6 3d^9$

12. a. B and D

b. Block of $B = d$ block

Period number of $B = 4$

Group number of $B = 2 + 5 = 7$

c. C

13. B. Statement 1 is correct, but 2 is not correct.

14. a. $1s^2 2s^2 2p^6 3s^2 3p^5$

b. s and p

c. $2l + 1 = 2 \times 1 + 1 = 3$

Another method

$l = 1 \Longrightarrow p\ subshell$

The p subshell has 3 orientations (orbitals)

15. a. $2p$

b. 3

c. Total number of orbitals in a shell $= n^2 = 2^2 = 4$

Another method

2^{nd} shell contains s and p subshells

The s subshell has 1 orbital, and the p subshell has 3 orbitals.

Total number of orbitals $= 1 + 3 = 4$