03

Classification of Elements and Periodicity in Properties

Quick Revision

1. **Modern Periodic Law and the Present Form of the Periodic Table**

- In 1913, the English physicist, Henry Moseley modified the Mendeleev's periodic table which is known as **modern periodic law**.
- This law can be stated as, "the physical and chemical properties of the elements are periodic functions of their atomic numbers."
- The modern periodic law is essentially the consequence of the periodic variation in electronic configurations which determine the physical and chemical properties of elements and their compounds.
- **Long form of periodic table** consist of horizontal rows called **periods** and the vertical columns called **groups** or families. It contains 7 periods and 18 groups.
- Elements having similar electronic configuration in their atoms are arranged in groups. The period number corresponds to the highest principal quantum number (n) of the elements.
- The first period contain 2 elements. The subsequent periods consists of 8, 8, 18, 18 and 32 elements respectively. The seventh period is incomplete and like the sixth period would have theoretical maximum of 32 elements.
- In this form of periodic table, 14 elements of both sixth and seventh periods (lanthanoids and actinoids respectively) are placed in separate panels at the bottom.

2. **Nomenclature of Elements with Atomic Numbers > 100**

The names are derived by using roots for the three digits in the atomic number of the elements followed by adding '–ium' at the end. The roots for the numbers are as

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

3. **Important Properties of *s*, *p*, *d* and *f*-block Elements**

(i) ***s*-block elements** General electronic configuration of elements of this block is ns^{1-2} (where, $n = 1, 2, \ldots$).

- Group I (alkali metals) and group II (alkaline earth metals) elements belongs to this block.
- These are reactive metals with low ionisation enthalpies.

- Their metallic and reactive character increases as on going down in a group.
- The compounds of *s*-block elements with exceptions of those of lithium and beryllium are predominantly ionic.

(ii) ***p*-block elements** The general configuration for these elements can be written as $ns^2\ np^{1\text{-}6}$ (where, $n = 1, 2, \ldots$).

- Group 13th to 18th excluding He, belongs to this block. Their last electron enters in *p*-block.
- *s* and *p*-block elements are known as representative elements or main group elements.
- Group 15 members are called **pnicogens**, group 16 members are called **chalcogens** and group 17 members are called **halogens**.

(iii) ***d*-block elements**

- Elements of 3rd to 12th in periodic table belongs to *d*-block.
- General electronic configuration of elements of this block is $(n-1)\ d^{1\text{-}10}\ ns^{(0-2)}$ where, $(n = 4\text{-}7)$.
- They are all metals. They mostly formed coloured ions, exhibit variable valence, paramagnetism and also used as catalyst.
- Zn, Cd and Hg have the electronic configuration $(n-1)\ d^{10}ns^2$, do not show most of the properties of transition elements.
- They are also called as **transition elements** as they form a bridge between the chemically active metals of *s*-block elements and the less active elements of group 13 and 14.

(iv) ***f*-block or inner transition elements**

- Last electron enters in *f*-orbital.
- General configuration is
  $ns^2\ (n-1)\ d^{0-10}\ (n-2)\ f^{\ 1-14}$
  where, $n = 6\text{-}7$
- Two series 4 *f* (lanthanoids) and 5 *f* (actinoids) belong to this block.

4. Valence Electrons

The electrons present in the outermost shell are called valence electrons.

(i) For ***s*-block elements,** group number is equal to the number of valence electrons.

(ii) For ***p*-block elements,** group number is equal to 10 + number of valence electrons.

(iii) For ***d*-block elements,** group number is equal to number of e^- in $(n-1)d$ subshell + number of electrons in valence shell.

5. Periodic Trends in Properties of Elements

(i) **Atomic radius** The atomic radius is defined as "the distance from the centre of the nucleus to the outermost shell of electrons."

Depending upon the nature of combining atoms, atomic radius can be of following types:

(a) **Covalent radius**

$$r_{\text{covalent}} = \frac{1}{2}$$

[Internuclear distance between two covalently bonded atoms]

(b) **Metallic radius** The one-half of the internuclear distance separating the metal cores in the metallic crystal.

(c) **van der Waals' radius** One-half of the distance between the nuclei of two identical non-bonded isolated atoms.

Variation of atomic radii in the periodic table are :

- **Variation along a period** The atomic radii generally decreases from left to right along a period. This is because, within a period, the electron is added to the same valence shell, due to which the effective nuclear charge increases and hence, the outer electron is held more tightly by the nucleus which results in decreased radii.
- **Variation in a group** The atomic radii generally increases on moving down the group. This is because the electrons are added in the successive shells, i.e. principal quantum number (n) increases and thus, the electrons of inner-shells shield the electrons of principal energy level from the pull of the nucleus, due to which the distance between the valence electron and the nucleus increases and hence, the atomic radii increases.

(ii) **Ionic radius** The ionic radius is defined as the effective distance from the centre of the nucleus of an ion upto which it has an influence in the ionic bond.

Internuclear distance = radii of cation + radii of anion

(a) **Variation of ionic radii** It shows same trend in the periodic table as shown by the atomic radii, i.e. decreases across a period and increases while moving down the group.

(b) **Isoelectronic species and their radii** These are neutral or ionic species which have the same number of electrons but different nuclear charges.

The ionic radii of isoelectronic ions increase with the decrease in the magnitude of the nuclear charge.

e.g. $Al^{3+} < Mg^{2+} < Na^{+} < Ne$.

(iii) **Ionisation enthalpy** (IE) The minimum amount of energy required to remove an electron from an isolated gaseous atom (X) in its ground state is called the ionisation enthalpy.

$$X\ (g) \longrightarrow X^{+}(g) + e^{-};\ \Delta_i H = +\text{ve}$$

or $X\ (g) + \Delta_i H \longrightarrow X^{+}(g) + e^{-}$

- **Variation of IE in periodic table** Generally, on moving left to right in period, IE increases and on moving down the group, it decreases. Half-filled orbitals and fully-filled orbitals are more stable thus, have high IE.

Various factors with which IE varies are

(a) **Atomic size** : varies inversely
(b) **Screening effect** : varies inversely
(c) **Nuclear charge** : varies directly

- **Exceptions** IE of elements of 2nd group is higher than the corresponding elements of thirteen group because of fully-filled configuration (ns^2).
- Similarly, IE of elements of group 15 is higher than corresponding elements of group 16 because of half-filled configuration (np^3).

(iv) **Electron gain enthalpy** ($\Delta e_g H$) When an electron is added to a gaseous atom in its ground state to convert it into a negative ion, the enthalpy change accompanying the process is called the electron gain enthalpy ($\Delta e_g H$).

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

Variation in periodic table Generally, on moving left to right in period, electron gain enthalpy increases and on moving down the group, it decreases.

Various factors affecting electron gain enthalpy are

- **Atomic size** : varies inversely
- **Nuclear charge** : varies directly
- **Configuration** Half-filled orbitals and fully-filled orbitals are stable form, therefore electron gain enthalpy will be low or even sometimes energy is required rather than getting released.
- **Exception** $Cl > F > S > O$ F and O-atom have small size and high charge density, but have lower electron gain enthalpy.
- Chlorine has highest electron affinity but oxidising power of fluorine is larger than chlorine.

(v) **Electronegativity** It is the ability of an atom of a compound to attract the shared pair of electrons towards itself.

6. **Variation of Electronegativity in the Periodic Table**

The variation of electronegativity in the periodic table is shown as follows :

(i) **Variation along a period** On moving from left to right across a period, as the effective nuclear charge increases and size decreases, the value of electronegativity increases due to increase in the attraction between the shared pair of electrons and the nucleus.

(ii) **Variation along a group** On moving down a group, as the atomic size increases, the force of attraction between the shared pair of electron and the nucleus decreases and, hence the electronegativity decreases.

Various factors which affect the magnitude of electronegativity are as follows :

(i) **Atomic radius** As the atomic radius of the elements increases, the electronegativity value decreases, i.e.

$$\text{Electronegativity} \propto \frac{1}{\text{Atomic radius}}$$

(ii) **Effective nuclear charge** The electronegativity value increases as the effective nuclear charge on the atomic nucleus increase. i.e.

Electronegativity $\propto$ Effective nuclear charge (Z_{eff})

(iii) **Oxidation state** The electronegativity increases as the oxidation state (i.e. the number of positive charge) of the atom increases.

(iv) **s-character** If the s-character in the hybridisation state of the central atom increases, electronegativity also increases.

Different scales of calculating electronegativity:

(a) Pauling scale

(b) Mulliken-Jaffe scale

7. Valency or Oxidation States

The valency is the most characteristic property of the elements and can be understood in terms of their electronic configuration. It is the combining power of an element.

Transition elements and actinoids also exhibit variable valency.

Variation of Valency in the Periodic Table

- Along a period from left to right, valency increases gradually from 1 to 4 with respect to hydrogen and then, decreases to 1 with respect to hydrogen.
- Valency of noble gases is taken as zero.In a group, all the elements have same valency because the number of valence electrons are same in them.

Objective Questions

Multiple Choice Questions

1. The long form of periodic table based on

(a) atomic volume
(b) atomic mass
(c) electronic configuration
(d) effective nuclear charge

2. Elements having similar outer shell electronic configuration in their atoms are arranged in

(a) groups (b) vertical columns
(c) families (d) All of these

3. The period number in the long form of the periodic table is equal to ***(NCERT Exemplar)***

(a) magnetic quantum number of any element of the period
(b) atomic number of any element of the period
(c) maximum principal quantum number of any element of the period
(d) maximum azimuthal quantum number of any element of the period

4. Successive filling of $3s$ and $3p$-orbitals give rise to the third period. The number of elements present in this period are

(a) 2 (b) 4 (c) 6 (d) 8

5. 14 elements of 6th period and 14 elements of 7th period in the periodic table are termed as respectively

(a) lanthanoids, actinoids
(b) actinoids, lanthanoids
(c) chalcogens, halogens
(d) actinoids, halogens

6. The elements in which electrons are progressively filled in $4f$-orbital are called ***(NCERT Exemplar)***

(a) actinoids
(b) transition elements
(c) lanthanoids
(d) halogens

7. Predict the position of an element having the electronic configuration $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5 4s^1$.

(a) Period 4, group 6 (b) Period 6, group 4
(c) Period 3, group 1 (d) Period 4, group 5

8. The group of elements in which the differentiating electron enters in the anti-penultimate shell of atoms are called

(a) f-block elements (b) p-block elements
(c) s-block elements (d) d-block elements

9. Cu $(Z = 29)$ is element of

(a) s-block (b) p-block
(c) d-block (d) f-block

10. An atom has electronic configuration $1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 3d^3, 4s^2$, you will place it in

(a) fifth group (b) fifteenth group
(c) second group (d) third group

11. In the periodic table, metals usually used as catalysts belong to

(a) f-block (b) d-block (c) p-block (d) s-block

12. The elements having characteristics of both metals and non-metals can be termed as

(a) semi-metals
(b) metalloids
(c) Either [(a) or (b)]
(d) amphoteric elements

13. The electronic configuration of four elements are

I. $[Xe]\,6s^1$ II. $[Xe]\,4f^{14}, 5d^1, 6s^2$
III. $[Ar]\,4s^2, 4p^5$ IV. $[Ar]\,3d^7, 4s^2$.

Which one of the following statements about these elements is not correct ?

(a) I is a strong reducing agent
(b) II is a d-block element
(c) III has high electron affinity
(d) IV shows variable oxidation state

14. The electronic configuration of gadolinium (Atomic number 64) is … .

(a) $[Xe]\,4f^3 5d^5 6s^2$ (b) $[Xe]\,4f^7 5d^2 6s^1$
(c) $[Xe]\,4f^7 5d^1 6s^2$ (d) $[Xe]\,4f^8 5d^6 6s^2$

15. Which of the following is not an actinoid ? ***(NCERT Exemplar)***

(a) Curium ($Z=96$) (b) Californium ($Z=98$)
(c) Uranium ($Z=92$) (d) Terbium ($Z=65$)

16. Match the Column I with Column II and select the correct answer using given codes.

Column I (Number of periods)		Column II (Number of elements)	
A.	First period	1.	14
B.	Third period	2.	2
C.	Lanthanoids	3.	8
D.	Actinoids	4.	4

Codes

	A	B	C	D
(a)	2	4	1	3
(b)	2	3	1	1
(c)	4	2	1	3
(d)	4	2	3	3

17. The name of the element with atomic number 105 is …… .

(a) kurchatovium (b) dubnium
(c) nobelium (d) holmium

18. An element with atomic number 112 has been made recently. It should be …… .

(a) an actinide
(b) a transition metal
(c) a noble gas
(d) a lanthanide

19. Match the Column I with Column II and choose the correct option using the codes given below :

Column I (Elements)		Column II (IUPAC name)	
A.	109	1.	Ununbium
B.	112	2.	Unnilennium
C.	115	3.	Ununpentium
D.	118	4.	Ununoctium

Codes

	A	B	C	D
(a)	1	2	3	4
(b)	2	1	3	4
(c)	1	2	4	3
(d)	2	1	4	3

20. If the bond distance in sodium molecule (Na) is 3.72 Å, then the radius of sodium is …… .

(a) 3.72Å (b) 1.86 Å
(c) 7.44 Å (d) 1.24 Å

21. Which of the following orders of ionic radius is correctly represented ?

(a) $H^- > H > H^+$ (b) $Na^+ > F^- > O^{2-}$
(c) $F^- > O^{2-} > Na^+$ (d) $Al^{3+} > Mg^{2+} > N^{3-}$

22. If the intermolecular distance between two adjacent copper atoms in solid copper is 256 pm, then the metallic radius of copper is …… .

(a) 128 pm (b) 12.87 Å
(c) 74 pm (d) 74 Å

23. Match the correct atomic radius with the element and choose the correct option using the codes given below.

Column I (Element)		Column II (Atomic radius (pm))	
A.	Be	1.	74
B.	C	2.	88
C.	O	3.	111
D.	B	4.	77
E.	N	5.	66

Codes *(NCERT Exemplar)*

	A	B	C	D	E
(a)	3	5	4	2	1
(b)	1	4	2	5	3
(c)	1	2	3	4	5
(d)	5	2	4	3	1

24. The increasing order of the atomic radii of the following elements is …… .

(*A*) C (*B*) O (*C*) F (*D*) Cl (*E*) Br

(a) (*A*) < (B) < (*C*) < (*D*) < (*E*)
(b) (*C*) < (*B*) < (*A*) < (*D*) < (*E*)
(c) (*D*) < (*C*) < (*B*) < (*A*) < (*E*)
(d) (B) < (*C*) < (*D*) < (*A*) < (*E*)

25. Consider the isoelectronic species, Na^+, Mg^{2+}, F^- and O^{2-}. The correct order of increasing length of their radii is …… . *(NCERT Exemplar)*

(a) $F^- < O^{2-} < Mg^{2+} < Na^+$
(b) $Mg^{2+} < Na^+ < F^- < O^{2-}$
(c) $O^{2-} < F^- < Na^+ < Mg^{2+}$
(d) $O^{2-} < F^- < Mg^{2+} < Na^+$

26. Few elements with first ionisation enthalpies are given in the table. Identify these elements.

Elements	IE_1(kJ/mol)
X	520
Y	2080
Z	899

(a) X = Noble gas, Y = alkali metal, Z = alkaline earth metal
(b) X = Noble gas, Y = alkaline earth metal, Z = alkali metal
(c) X = alkali metal, Y = Noble gas, Z = alkaline earth metal
(d) X = alkaline earth metal, Y = Noble gas, Z = alkali metal

27. The element having highest ionisation energy would be

(a) He (b) Be
(c) N (d) F

28. The first ionisation enthalpies of Na, Mg, Al and Si are in the order

(a) Na < Mg > Al < Si
(b) Na > Mg > Al > Si
(c) Na < Mg < Al < Si
(d) Na > Mg > Al < Si

29. The energy required in the equation,

$X^+(g) \longrightarrow X^{2+}(g) + e^-$ represents

(a) first ionisation enthalpy
(b) second ionisation enthalpy
(c) electronegative character
(d) electron gain enthalpy

30. Amongst the following, select the element having highest ionisation enthalpy.

(a) Sodium (b) Potassium
(c) Beryllium (d) Magnesium

31. The correct order of electron affinities of N, O, S and Cl is

(a) N < O < S < Cl
(b) O < N < Cl < S
(c) O ≈ Cl < N ≈ S
(d) O < S < Cl < N

32. Which of the following pair contain will have the most negative and least negative electron gain enthalpy respectively, P, S, Cl and F ?

(a) P and Cl (b) S and Cl
(c) Cl and F (d) Cl and P

33. Electronic configuration of some elements is given in Column I and their electron gain enthalpies are given in Column II. Match the electronic configuration with electron gain enthalpy.

	Column I (Electronic configuration)	Column II (Electron gain enthalpy/ kJ mol^{-1})
A.	$1s^2\ 2s^2\ 2p^6$	– 53
B.	$1s^2\ 2s^2\ 2p^6\ 3s^1$	– 328
C.	$1s^2\ 2s^2\ 2p^5$	– 141
D.	$1s^2\ 2s^2\ 2p^4$	+ 48

Codes *(NCERT Exemplar)*

	A	B	C	D		A	B	C	D
(a)	1	2	3	4	(b)	4	1	2	3
(c)	3	2	1	4	(d)	1	2	4	3

34. The increasing order of the density of alkali metals is ....

(a) Li < K < Na < Rb < Cs (b) Li < Na < K < Rb < Cs
(c) Cs < Rb < Na < K < Li (d) Cs < Rb < K < Na < Li
(e) Li < Na < Rb < K < Cs

35. The ability of an atom in a chemical compound to attract shared electron is termed as ....

(a) electron affinity (b) ionisation enthalpy
(c) atomic attraction (d) electronegativity

36. The correct order of decreasing electronegativity values among the elements

I-beryllium, II-oxygen, III-nitrogen and IV-magnesium, is

(a) II > III > I > IV
(b) III > IV > II > I
(c) I > II > III > IV
(d) I > II > IV > III

37. The correct order of electronegativity of N, O and F is ....

(a) N > O > F (b) O > F > N
(c) O > N > F (d) F > O > N

38. What will be the electronegativity of carbon at Pauling scale?

Given that $E_{H-H} = 104.2$ kcal mol^{-1},

$E_{C-C} = 83.1$ kcal mol^{-1}

$E_{C-H} = 98.8$ kcal mol^{-1}

Electronegativity of hydrogen = 2.1

(a) 0.498 (b) 0.598
(c) 2.134 (d) 2.598

39. The increasing order of electronegativity of C, N, P and Si element will be ....

(a) C, N, Si, P
(b) N, Si, C, P
(c) Si, P, C, N
(d) P, Si, N, C

40. Match Column I with Column II and select the correct answer using given codes.

Column I (Atoms)		Column II (Properties)	
A.	He	1.	High electronegativity
B.	F	2.	Most electropositive
C.	Rb	3.	Strongest reducing agent
D.	Li	4.	Highest ionisation energy

Codes

	A	B	C	D
(a)	4	2	3	1
(b)	1	4	2	3
(c)	4	1	3	2
(d)	4	1	2	3

41. Match the element (in Column I) with its unique properties (in Column II).

Column I		Column II	
A.	F	1.	Maximum ionisation energy
B.	Cl	2.	Maximum electronegativity
C.	Fe	3.	Maximum electron affinity
D.	He	4.	Recently named by IUPAC
E.	Ds	5.	Variable valence

Codes

	A	B	C	D	E
(a)	5	4	1	2	3
(b)	3	4	2	1	5
(c)	2	3	5	1	4
(d)	3	1	4	2	5

Assertion-Reasoning MCQs

Directions In the following questions (Q.No. 42-55) a statement of Assertion followed by a statement of Reason is given. Choose the correct answer out of the following choices.

(a) Both Assertion and Reason are correct statements and Reason is the correct explanation of the Assertion.
(b) Both Assertion and Reason are correct statements, but Reason is not the correct explanation of the Assertion.
(c) Assertion is correct, but Reason is incorrect statement.
(d) Assertion is incorrect but Reason is correct statement.

42. **Assertion** Noble gases are highly reactive.

Reason Noble gases have stable outer electronic configuration.

43. **Assertion** Element in the same vertical column have similar properties.

Reason Elements have periodic dependence upon the atomic number.

44. **Assertion** The elements having $1s^2, 2s^2, 2p^6, 3s^2$ and $1s^2, 2s^2$ electronic configuration belong to same period.

Reason Both have same outermost electronic configuration.

45. **Assertion** Atomic number of the element copernicium is 112.

Reason IUPAC name of this element is ununbium in which un-and bi-are used for 1 and 2 respectively in Latin words.

46. **Assertion** The atomic radii of the elements of the oxygen family are smaller than the atomic radii of the corresponding elements of the nitrogen family.

Reason The members of the oxygen family are more electronegative and thus, have lower values of nuclear charge than those of the nitrogen family.

47. **Assertion** Isoelectronic species have same radii.

Reason They contain different number of electrons.

48. **Assertion** The atomic and ionic radii generally decrease towards right in a period.

Reason The ionisation enthalpy decreases on moving towards left in a period.

49. **Assertion** Boron has a smaller first ionisation enthalpy than beryllium.

Reason The penetration of $2s$ electron to the nucleus is more than the $2p$ electron. Hence, $2p$ electron is more shielded by the inner core of electrons than the $2s$ electrons. ***(NCERT Exemplar)***

50. **Assertion** Ionisation enthalpy is the energy released to remove an electron from an isolated gaseous atom in its ground state.

Reason Element which has a tendency to lose the electron to attain the stable configuration.

51. **Assertion** Generally, ionisation enthalpy increases from left to right in a period.

Reason When successive electrons are added to the orbitals in the same principal quantum level, the shielding effect of inner core of electrons does not increase very much to compensate for the increased attraction of the electron to the nucleus.

52. **Assertion** Alkali metals have least value of ionisation energy within a period.

Reason They precedes alkaline earth metals in periodic table.

53. **Assertion** Electron gain enthalpy becomes less negative as we go down a group.

Reason Size of the atom increases on going down the group and the added electron would be farther from the nucleus.

54. **Assertion** Cesium and fluorine both reacts violently.

Reason Cesium is most electropositive and fluorine is most electronegative.

55. **Assertion** Fluorine has a less negative electron affinity than chlorine.

Reason There is relatively greater effectiveness of $2p$ electrons in the small fluorine atom to repel the additional electron entering the atom than to $3p$ electrons in the larger Cl atom.

Case Based MCQs

56. Read the passage given below and answer the following questions:

When an electron is added to a gaseous atom in its ground state to convert it into a negative ion, the enthalpy change accompanying the process is called the electron gain enthalpy ($\Delta e_g H$). It is a direct measure of the ease with which an atom attracts an electron to form anion.

$X(g) + e^- \longrightarrow X^-(g)$; $\Delta H = \Delta e_g H$

The most stable state of an atom is the ground state. If an isolated gaseous atom is in excited state, comparatively lesser energy will be released on adding an electron. So, electron gain enthalpies of gaseous atoms must be determined in their ground states. Therefore, the terms ground state and isolated gaseous atom has been also included in the definition of electron gain enthalpy. Like ionisation enthalpy, electron gain enthalpy is measure either in electron volts per atom or kJ per mole.

The following questions (i-iv) are multiple choice questions. Choose the most appropriate answer :

(i) Noble gases have positive electron gain enthalpy due to
(a) stable configuration
(b) large size
(c) high reactivity
(d) unstable configuration

(ii) The electron gain enthalpy of O or F is less than that of S or Cl. It is due to
(a) small size
(b) less repulsion
(c) large size
(d) high electronegativity

(iii) The electron gain enthalpy (in kJ/mol) of fluorine, chlorine, bromine and iodine, respectively, are
(a) $-333, -325, -349$ and -296
(b) $-296, -325, -333$ and -349
(c) $-333, -349, -325$ and -296
(d) $-349, -333, -325$ and -296

(iv) Why beryllium has higher ionisation enthalpy than boron ?
(a) More penetration of s-electron
(b) More penetration of p-electron
(c) Large size
(d) Small size

Or

Factors affecting electron gain enthalpy is
(a) atomic size
(b) number of electrons
(c) number of neutron
(d) None of the above

57. Read the passage given below and answer the following questions :

Comprehension given below is followed by some multiple choice questions. Each question has one correct option. Choose the correct option.

In the modern periodic table, elements are arranged in order of increasing atomic numbers which is related to the electronic configuration.

Depending upon the type of orbitals receiving the last electron, the elements in the periodic table have been divided into four blocks, *viz., s, p, d* and *f.*

The modern periodic table consists of 7 periods and 18 groups. Each period begins with the filling of a new energy shell. In accordance with the Aufbau principle, the seven periods (1 to 7) have 2, 8, 8, 18, 18, 32 and 32 elements respectively.

The seventh period is still incomplete. To avoid the periodic table being too long, the two series of *f*-block elements, called lanthanoids and actinoids are placed at the bottom of the main body of the periodic table.

The following questions (i-iv) are multiple choice questions. Choose the most appropriate answer:

(i) The element with atomic number 57 belongs to

(a) *s* - block (b) *p* - block
(c) *d* - block (d) *f* - block

(ii) The last element of the *p*-block in 6th period is represented by the outermost electronic configuration.

(a) $7s^2\ 7p^6$ (b) $5f^{14}\ 6d^{10}\ 7s^2\ 7p^0$
(c) $4f^{14}\ 5d^{10}\ 6s^2\ 6p^6$ (d) $4f^{14}\ 5d^{10}\ 6s^2\ 6p^4$

(iii) Which of the following elements, whose atomic numbers are given below, cannot be accommodated in the present set up of the long form of the periodic table?

(a) 107 (b) 118
(c) 126 (d) 102

(iv) The electronic configuration of the element which is just above the element with atomic number 43 in the same group is ....

(a) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^5\ 4s^2$
(b) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^5\ 4s^3\ 4p^6$
(c) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^6\ 4s^2$
(d) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^7\ 4s^2$

Or The elements with atomic numbers 35, 53 and 85 are all ....

(a) noble gases (b) halogens
(c) heavy metals (d) light metals

58. Read the passage given below and answer the following questions :

Moseley modified Mendeleev periodic law. He stated "physical and chemical properties of elements are the periodic function of their atomic numbers." It is known as modern periodic law and considered as the basis of modern periodic table.

When the elements were arranged in increasing order of atomic numbers, it was observed that the properties of elements were repeated after certain regular intervals 01 2, 8, 8, 18, 18 and 32. These numbers are called magic numbers and cause of periodicity in properties due to repetition of similar electronic configuration. Long form of periodic table is called Bohr's periodic table. There are 18 groups and seven periods in this periodic table. The horizontal rows are called periods.

First period ($_1$H - $_2$He) contains 2 elements. It is the shortest period. Second period ($_3$Li - $_{10}$Ne) and third period ($_{11}$Na - $_{18}$Ar) both contains 8 elements each. Fourth period ($_{19}$K - $_{36}$Kr) and fifth period ($_{37}$Rb - $_{54}$Xe) contain 18 elements each. These are long periods.

Sixth period ($_{55}$Cs - $_{86}$Rn) consists of 32 elements and is the longest period. Seventh period starting with $_{87}$Fr is incomplete and consists of 19 elements. Elements of group 1 are called alkali metals. Elements of group 2 are called alkaline earth metals. Elements of group 16 are called chalcogens [ore forming elements).Elements of group 17 are called halogens [sea salt forming]. Elements of group 18 are called noble gases.

Anomalous behaviour of the first element of a group. The first element of a group differs considerably from its congeners (i.e. the rest of the elements of its group).

This is due to (i) small size (ii) high electro-negativity and (iii) non-availability of *d*-orbitals for bonding. Anomalous behaviour is observed among the second row elements (i.e. Li to F).

In these questions (i-iv) a statement of Assertion followed by a statement of Reason is given. Choose the correct answer out of the following choices :

(a) Assertion and Reason both are correct statements and Reason is correct explanation for Assertion.
(b) Assertion and Reason both are correct statements but Reason is not correct explanation for Assertion.
(c) Assertion is correct statement but Reason is incorrect statement.
(d) Assertion is incorrect statement but Reason is correct statement.

(i) **Assertion** Zinc is a *d*-block element.
Reason Zinc does not form coordination compounds.

(ii) **Assertion** The first ionisation enthalpy of Be is greater that that of C.
Reason $2p$-orbital is lower in energy than $2s$-orbital.

(iii) **Assertion** Outermost electronic configuration of most electronegative element is ns^2np^7.
Reason Most electronegative elements are halogen.

(iv) **Assertion** Mn has less favourable electron affinity than its neighbours in either side.
Reason The magnitude of electron affinity depends on the electronic configuration of the atom.

Or

Assertion Generally, ionisation enthalpy increases from left to right in a period.
Reason When successive electrons are added to the orbitals in the same principal quantum level, the shielding effect of inner core of electrons does not increase very much to compensate for the increased attraction of electrons to the nucleus.

59. Read the passage given below and answer the following questions:

In 1913, **Henry Moseley,** the English physicist performed an experiment by bombarding high speed electrons on 38 different elements starting from aluminium and ending with gold in vacuum and generated X-rays. He observed that the square root of the frequency (ν) of the X-rays emitted by a metal is proportional to the atomic number and not to the atomic weight of the element of the electron,

i.e. $\sqrt{x} = a(Z - b)$

[where, a and b = constants].

Thus, when $\sqrt{\nu}$ is plotted with atomic number (Z), a straight line is obtained, but this is not true when $\sqrt{\nu}$ is plotted with atomic mass. He postulated that the atomic number is a more fundamental property of an element than its atomic mass.

Thus, he modified the Mendeleev's periodic law and gave modern periodic law, which states that.

"The physical and chemical properties of the elements are the periodic function of their atomic numbers," i.e. when elements are arranged in increasing order of atomic numbers, the elements having similar properties are repeated after certain regular intervals.

In these questions (i -iv), a statement of Assertion followed by a statement of Reason is given. Choose the correct answer out of the following choices.

(a) Assertion and Reason both are correct statements and Reason is correct explanation for Assertion.
(b) Assertion and Reason both are correct statements but Reason is not correct explanation for Assertion.
(c) Assertion is correct statement but Reason is incorrect statement.
(d) Assertion is incorrect statement but Reason is correct statement.

(i) **Assertion** Mendeleev's arranged elements in horizontal rows and vertical columns.

Reason Mendeleev's ignored the order of atomic weight thinking that the atomic measurements might be incorrect.

(ii) **Assertion** Mendeleev's left the gap under aluminium and silicon and called these Eka-aluminium and Eka-silicon, respectively.

Reason Dobereiner arranged elements on the basis of increasing atomic number.

(iii) **Assertion** The horizontal rows in the periodic table are called periods or Mendeleev's series.

Reason Elements having similar outer electronic configurations in their atoms are arranged in groups/families.

(iv) **Assertion** Sixth period is the longest period in the periodic table.

Reason Sixth period involves the filling of all the orbitals of sixth energy level.

Or **Assertion** The elements having $1s^2, 2s^2, 2p^6, 3s^2$ and $1s^2, 2s^2$ electronic configuration belong to same period.

Reason Both have same outermost electronic configuration.

60. Read the passage given below and answer the following questions :

Elements having a place within the group 13 (i.e. group IIIA) to group 17 (i.e. group VIIA) of the periodic table alongside the group 18, i.e. the zero group elements together frame the *p*-block of the periodic table.

In the elements of *p*-block, the last electron enters the furthest *p*-orbital. They have 3 to 8 electrons in the peripheral shell. As we realise that the quantity of *p*-orbitals is three and, therefore, the most extreme number of electrons that can be obliged in an arrangement of *p*-orbitals is six. Consequently, there are six groups of *p*-block elements in the periodic table.

In the *p*-block, all the three sorts of elements are available, i.e. the **metals, non-metals** and **metalloids**. The crisscross line in the *p*-block isolates the elements that are metals from those that are non-metals. Metals are found on the left of the line and non-metals are those on the right. Along the line, we discover the metalloids. Because of the nearness of a wide range of elements, the *p*-block demonstrates a great deal of variety in properties.

The general valence shell electronic design of *p*-block elements is $ns^2\ np^{1-6}$ (with the exception of He). The internal core of the electronic arrangement may although contrast.

In these questions (i-iv), a statement of Assertion followed by a statement of Reason is given. Choose the correct answer out of the following choices.

(a) Assertion and Reason both are correct statements and Reason is correct explanation for Assertion.
(b) Assertion and Reason both are correct statements but Reason is not correct explanation for Assertion.
(c) Assertion is correct statement but Reason is incorrect statement.
(d) Assertion is incorrect statement but Reason is correct statement.

(i) **Assertion** The ionisation of *s*-electrons requires more energy then that for the ionisation of *p*-electrons of the same shell.

Reason *s*-electrons are closer to nucleus than *p*-electrons and hence are more strongly attracted by nucleus.

(ii) **Assertion** The first ionisation energy of Al is lower than that of Mg.

Reason Ionic radius of Al is smaller than that of Mg.

(iii) **Assertion** F is more electronegative than Cl.

Reason F has higher electron affinity than Cl.

(iv) **Assertion** Boron differs from Al and other members of group 13 in a number of properties.

Reason B does not show anomalous behaviour.

Or **Assertion** Carbon forms large number of stable compounds.

Reason Carbon is less electropositive as compared to other members of group 14.

ANSWERS

Multiple Choice Questions

1. (c)	*2. (d)*	*3. (c)*	*4. (d)*	*5. (a)*	*6. (c)*	*7. (a)*	*8. (a)*	*9. (c)*	*10. (a)*
11. (b)	*12. (c)*	*13. (b)*	*14. (c)*	*15. (d)*	*16. (b)*	*17. (b)*	*18. (b)*	*19. (b)*	*20. (b)*
21. (a)	*22. (a)*	*23. (a)*	*24. (b)*	*25. (b)*	*26. (c)*	*27. (a)*	*28. (a)*	*29. (b)*	*30. (c)*
31. (a)	*32. (d)*	*33. (b)*	*34. (a)*	*35. (d)*	*36. (a)*	*37. (d)*	*38. (d)*	*39. (c)*	*40. (d)*
41. (c)									

Assertion-Reasoning MCQs

42. (d)	*43. (a)*	*44. (d)*	*45. (b)*	*46. (c)*	*47. (d)*	*48. (c)*	*49. (a)*	*50. (d)*	*51. (a)*
52. (b)	*53. (a)*	*54. (a)*	*55. (a)*						

Case Based MCQs

56. (i)-(a), (ii)-(a), (iii)-(c), (iv)-(a) or-(a)

57. (i)-(c), (ii)-(c), (iii)-(b), (iv)-(a) or-(b)

58. (i)-(c), (ii)-(c), (iii)-(d), (iv)-(a) or-(b)

59. (i)-(b), (ii)-(c), (iii)-(b), (iv)-(c) or-(d)

60. (i)-(a), (ii)-(b), (iii)-(c), (iv)-(c) or-(c)

EXPLANATIONS

1. The long form of periodic table is based on electronic configuration of elements, i.e. Bohr-Bury concept.

2. Similar outer configuration in their atoms are arranged in vertical columns called groups or families.

3. Since each period starts with the filling of electrons in a new principal quantum number, therefore, the period number in the long form of the periodic table refers to the maximum principal quantum number of any element in the period.

Period number = maximum n of any element (where, n = principal quantum number).

4. Successive filling of $3s$ and $3p$-orbitals give rise to the third period of 8 elements from sodium to argon.

5. 14 elements of 6th period are called lanthanoids and those of 7th period are termed as actinoids.

6. The elements in which electrons are progressively filled in $4f$-orbital are called lanthanoids. Lanthanoids consist of elements from $Z = 58$ (cerium) to 71 (lutetium).

7. $n = 4$ hence, element lies in 4th period.

Group $= ns + (n-1)\,d = 1 + 5 = 6$

8. The group of elements in which the differentiating electron enters in the anti-penultimate shell, inner to the penultimate shell, i.e. $(n-2)$ shell is called f-block elements or inner-transition elements.

9. Electronic configuration of Cu

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

Hence, in this element, the last electron enters in one of the inner d-orbital. Thus, Cu is the element of d-block.

10. An atom has electronic configuration,

$$1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 3d^3, 4s^2.$$

It is a member of d-block elements because the last electron is filled in d-subshell as $3d^3$. Group number of a d-block element

$$= ns\text{-electron} + (n-1)\ d\text{-electrons} = 2 + 3 = 5.$$

Hence, it is a member of fifth group.

11. Metals which are usually used as catalysts belong to d-block of the periodic table, e.g. Ni, Pt, etc., as they have large surface area.

12. The elements such as silicon, germanium, arsenic, antimony and tellurium have characteristics of both metals and non-metals and are termed as semi-metals or metalloids.

13. $[Xe]\ 4f^{14}, 5d^1, 6s^2$ is not a d-block element.

It is lutetium and is present in lanthanide series. So, lutetium is a f-block element.

$[Xe]\ 6s^1$ is a strong reducing agent as by losing one electron it acquires stable electronic configuration.

$[Ar]4s^2 4p^5$ has high electron affinity as by gaining one electron, it acquires stable electronic configuration.

$[Ar]3d^7 4s^2$ is a d-block element and it shows variable oxidation states.

Note The generalised electronic configuration of f-block elements is $(n-2)\ f^{1\text{-}14}\ (n-1)\ d^{0\text{-}1} ns^2$.

14. The electronic configuration of La $(Z = 57)$ is $[Xe]\ 5d^1\ 6s^2$. Therefore, further addition of electrons occurs in the lower energy $4f$-orbital till it is exactly half-filled at Eu $(Z = 63)$.

Thus, the electronic configuration of Eu is $[Xe]\ 4f^7\ 6s^2$.

Thereafter, addition of next electron does not occur in the more stable exactly half-filled $4f^7$ shell but occurs in the little higher energy $5d$-orbital.

Thus, the electronic configuration of Gd $(Z = 64)$ is $[Xe]\ 4f^7\ 5d^1\ 6s^2$.

15. Elements with atomic number, $Z = 90$ to 103 are called actinoids.

Thus, terbium $(Z = 65)$ is not an actinoid. Terbium belong to lanthanoids.

16. The correct match is

$$A \rightarrow 2;\ B \rightarrow 3;\ C \rightarrow 1,\ D; \rightarrow 1.$$

(A) First period contains 2 elements.

(B) Third period contains 8 elements.

(C) and (D). 14 elements of both sixth period [from $Z = 58$ to $Z = 71$] and seventh period [from $Z = 90$ to $Z = 103$] are known as lanthanoids and actinoids respectively.

17. The element with atomic number 105 is dubnium (Db). In IUPAC nomenclature, it is known as unnilpentium.

$$\text{Db}(105) = [\text{Rn}]^{86} 5f^{14}\ 6d^3\ 7s^2$$

18. The electronic configuration of given element with atomic number 112 is $[\text{Rn}]_{86}$ $5f^{14}, 7s^2, 6d^{10}$. As its outermost electron enters in d-subshell, thus it belongs to d-block or a transition metal.

19. Correct match is

$$A \rightarrow (2);\ B \rightarrow (1);\ C \rightarrow (3);\ D \rightarrow (4)$$

109 – Unnilennium

112 – Ununbium

115 – Ununpentium

118 – Ununoctium

20. Radius of Na-atom

$$= \frac{\text{Bond distance of Na}}{2} = \frac{3.72\ \text{Å}}{2} = 1.86\ \text{Å}$$

21. Option (a) is correct.

(a) $H^- > H > H^+$

It is known that radius of a cation is always smaller than that of a neutral atom because it has fewer electrons while its nuclear charge remains the same.

Whereas, the radius of anion is always greater than neutral atom due to decrease in effective nuclear charge.

Hence, the given order is correct.

(b) The given species, in option (b) are isoelectronic as they contain same number of electrons.

For isoelectronic species,

$$\text{ionic radius} \propto \frac{1}{\text{atomic number}}$$

Ion —	Na^+	F^-	O^{2-}
Atomic number —	11	9	8

Hence, the correct order of ionic radius is

$$O^{2-} > F^- > Na^+$$

(c) Similarly, the correct option is

$$O^{2-} > F^- > Na^+.$$

(d) Ion — Al^{3+} Mg^{2+} N^{3-}

Atomic number — 13 12 7

Hence, the correct order is

$$N^{3-} > Mg^{2+} > Al^{3+}.$$

22. Internuclear distance between Cu-atoms in solid copper $= 256$ pm.

Metallic radius $= \frac{1}{2} \times$ length between two atoms

$$= \frac{1}{2} \times 256 = 128 \text{ pm}$$

23. All the given elements are of same period and along a period, atomic radii decreases because effective nuclear charge increases.

Thus, the order of atomic radii is

$O < N < C < B < Be$ or, $Be = 111$ pm,

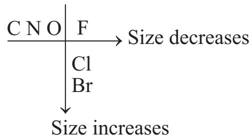
$O = 66$ pm, $C = 77$ pm, $B = 88$ pm, $N = 74$ pm.

24. Atomic radius generally decreases as we compare elements in a period from left to right,

$\therefore \quad C > O > F$

but elements present in next period are larger in size,

$\therefore \quad Br > Cl > C > O > F$;



So, the correct increasing order of the atomic radii, $C < B < A < D < E$.

25. In case of isoelectronic species ionic radii

$$\propto \frac{1}{\text{atomic number}}$$

The ionic radii increases as the positive charge decreases or the negative charge increases.

Ion $Mg^{2+} < Na^{+} < F^{-} < O^{2-}$

Atomic number (12) (11) (9) (8)

26. I.E. of noble gases are maximum, whereas that of alkali metal is least. I.E. of alkaline earth metal is higher than alkali metal but lower than subsequent elements, thus X is an alkali metal, Y is a noble gas and Z is an alkaline earth metal.

27. Helium possesses a stable configuration $1s^2$.
In it, the K-shell is completely filled. This is why, the ionisation energy of helium is much greater than another elements.

28. Follow the following steps to solve out such problems

Steps	Method	Apply
Step I	Write the electronic configuration to find position in the periodic table	$_{11}Na = [Ne]\ 3s^1$, $_{12}Mg = [Ne]\ 3s^2$ $_{13}Al = [Ne]\ 3s^2\ 3p^1$, $_{14}Si = [Ne]\ 3s^2\ 3p^2$
Step II	Arrange them in the order as they are placed in the periodic table	11 Na, 12 Mg, 13 Al, 14 Si
Step III	Follow the general trend and also keep in mind the exception	The IP increases along a period from left to right but IP of Mg is higher than that of Al due to completely filled $3s$ orbital in Mg.
Step IV	On the above basis find the order	The order of IP is $Na < Mg > Al < Si$. Thus, option (a) is the correct.

29. Second ionisation enthalpy is defined as the energy required to remove the second most loosely bounded electron. Hence, the amount of energy required in the given equation represents second ionisation enthalpy.

$$X^{+}(g) \longrightarrow X^{2+}(g) + e^{-}$$

30. Ionisation enthalpy increases on moving from left to right in a period and decreases on moving down in a group. Thus, order of ionisation enthalpy is $Be > Mg > Na > K$.

31. Generally, electron affinity increases on moving from left to right in a period and decreases on moving down in a group. Electron affinities of second period elements (such as N, O) are less negative as compared to corresponding third period element. This is because of the small atomic size of second period elements. Hence, the correct order of electron affinities is
$N < O < S < Cl$.

32. Electron gain enthalpy generally becomes more negative across a period, as we move from left to right. Within a group, electron gain enthalpy becomes less negative down the group. However, adding an electron to the $2p$ orbital leads to greater repulsion than adding an electron to the larger $3p$-orbital.

Chlorine (Cl) has most negative electron gain enthalpy, while phosphorus (P) has least negative electron gain enthalpy.

33. $A \rightarrow (4)$; $B \rightarrow (1)$; $C \rightarrow (2)$; $D. \rightarrow (3)$

A. This electronic configuration corresponds to the noble gas i.e., neon. Since, noble gases have $+\Delta e_g H$ values, therefore, electronic configuration (A) corresponds to the d $\Delta e_g H = +48$ kJ mol^{-1}.

B. This electronic configuration corresponds to the alkali metal, i.e. potassium.

Alkali metals have small negative $\Delta e_g H$ values, hence, electronic configuration (B) corresponds to $\Delta e_g H = -53$ kJ mol^{-1}.

C. This electronic configuration corresponds to the halogen, i.e. fluorine. Since, halogens have high negative $\Delta e_g H$ values, therefore, electronic configuration (C) corresponds to $\Delta e_g H = -328$ kJ mol^{-1}.

D. This electronic configuration corresponds to the chalcogen, i.e. oxygen.

Since, chalcogens have $\Delta e_g H$ values less negative than those of halogens, therefore, electronic configuration (D) corresponds to $\Delta e_g H = -141$ kJ mol^{-1}.

34. On moving downward in a group, density increases but the density of K is somewhat lesser than that of Na. Due to abnormal increase in size of K atom.

Thus, the order of density is

Li < K < Na < Rb < Cs.

Densities are

Li - 0.53 g/cc, Na - 0.97 g/cc,
K - 0.86 g/cc, Rb - 1.53 g/cc and
Cs - 1.90 g/cc.

35. A qualitative measure of the ability of an atom in a chemical compound to attract shared electrons to itself is called electronegativity.

36. Electronegativity increases along a period and decreases in a group. Thus, the order is II > III > I > IV.

Electronegativity of O = 3.5,
N = 3.0, Be = 1.5, Mg = 1.2

37. Electronegativity increases on moving from left to right in a period.

So, the correct order of electronegativity of N, O and F is F > O > N.

38. $\chi_C - \chi_H = 0.208\sqrt{\Delta}$

where, $\Delta = E_{C-H} - \sqrt{E_{C-C} \times E_{H-H}}$

$\Delta = 98.8 - \sqrt{83.1 \times 104.2}$

$\therefore \quad \Delta = 5.75$

$\chi_C - 2.1 = 0.208\sqrt{5.75} = 0.497$

$\chi_C = 2.598$

39. In general, the electronegativity increases on moving from left to right in a period. Hence, the increasing order of electronegativity is as follows

Si < P < C < N

40. The correct match is

$A \rightarrow 4$, $B \rightarrow 1$, $C \rightarrow 2$, $D \rightarrow 3$

Helium (He) $1s^2$	$\longrightarrow$	Highest ionisation energy due to noble gas in nature and small size.
Fluorine (F) $1s^2, 2s^2 2p^5$	$\longrightarrow$	High electronegativity in nature due to small size and −1 oxidation state.
Rubidium (Rb) [Kr]$5s^1$	$\longrightarrow$	Most electropositive element due to large atomic size.
Lithium (Li) $1s^2 2s^1$	$\longrightarrow$	Strongest reducing agent due to small size and positive oxidation state (+1).

41. Correct match is $A \rightarrow (2)$; $B \rightarrow (3)$; $C \rightarrow (5)$; $D \rightarrow (1)$; $E \rightarrow (4)$

- F – Maximum electronegativity
- Cl – Maximum electron affinity
- Fe – Variable valence
- He – Maximum ionisation energy
- Ds – Recently named by IUPAC

42. Noble gases are very less reactive due to stable outer electronic configuration like ns^2np^6 or ns^2.

Thus, R is correct but A is incorrect.

43. Both (A) and (R) are correct statements and (R) is the correct explanation of (A).

Elements in same group have same number of electrons in the outer orbitals and similar electronic configuration. Therefore, they have similar properties..

44. $2p^6, 3s^2 \longrightarrow$ Belongs to 3rd period

$1s^2, 2s^2 \longrightarrow$ Belongs to 2nd period

Both have ns^2, i.e. same electronic configuration. Hence, both belongs to different period.

Thus, Reason is correct but Assertion is incorrect.

45. IUPAC name of element copernicium having atomic number 112 is ununbium, for 1, suffix 'un' and for 2 suffix 'bi' is used which are Latin words.

Thus, Both (A) and (R) are the correct statements but (R) is not the correct explanation of (A).

46. The atomic radii of the elements of oxygen family are smaller than atomic radii of the corresponding elements of the nitrogen family because of increase in effective nuclear charge the results in the increased attraction of electrons to the nucleus.

Thus, (A) is correct statement but (R) is a incorrect statement.

47. Isoelectronic species have different radii because of their different nuclear charges.

Thus, (A) is incorrect statement but (R) is a correct statement.

48. The atomic and ionic radii decrease in a period from left to right due to increase in effective nuclear charge. The ionisation enthalpy increases on moving left to right in period.

Thus, Assertion is correct but Reason is incorrect.

49. Boron has a smaller first ionisation enthalpy than beryllium because the penetration of $2s$ electron to the nucleus is more than the $2p$ electron. Hence, $2p$ electron is more shielded by the inner core of electrons than the $2s$ electron.

Thus, both (A) and (R) statements are correct and (R) is the correct explanation of statement (A).

50. Ionisation enthalpy is the energy required to remove an electron from an isolated gaseous atom in its ground state. Every element does not have tendency to lose electrons. Thus, (A) statement is incorrect but (R) statement is correct.

51. Assertion and reason both are correct statements and reason is correct explanation of assertion. lonisation enthalpy increases along a period because effective nuclear charge increases and atomic size decreases.

Hence, both (A) and (R) are correct statement and (R) is the correct explanation of (A).

52. Both (A) and (R) are correct statements but (R) is not the correct explanation of (A).

Alkali metals belong to first group and have larger size in a period and hence have low I.E.

53. Both (A) and (R) are correct statements and (R) is the correct explanation for (A).

Electron gain enthalpy becomes less negative as the size of an atom increases down the group.

This is because within a group screening effect increases on going down in a group and the added electron would be farther away from the nucleus.

54. Both (A) and (R) are correct statements and (R) is the correct explanation of (A).

Cesium and fluorine both reacts violently because cesium is most electropositive and fluorine is most electronegative.

55. Fluorine has a less negative electron affinity than chlorine. There is relatively greater effectiveness of $2p$ electrons in the small fluorine atom to repel the additional electron entering the atom than to $3p$ electrons in the larger Cl atom.

Hence, both (A) and (R) are correct statement and (R) is the correct explanation of (A).

56. (i) Due to stable configuration noble gas do not accept an electron and hence they have positive electron gain enthalpy.

(ii) There is more repulsion for the incoming electron when the size of atom is small.

When an electron is added to O or F, it goes to a smaller ($n = 2$) level and suffers more repulsion than the electron in S or Cl in larger level ($n = 3$).

(iii) Electron gain enthalpy ($\Delta_{e_g}H$) is the enthalpy change for converting 1 mol of isolated atoms to anions by adding electrons. All halogens have negative $\Delta_{e_g}H$ (exothermic) values. Generally, $\Delta_{e_g}H$ becomes less negative when comparing elements of the same group from top to bottom.

But among fluorine and chlorine there is an anomaly because inter-electron repulsion is stronger in fluorine due to its extra small size.

$\therefore$ $\Delta e_g H$ is less exothermic than expected for F-atom.

Thus, the correct values of electron gain enthalpies

$$\underset{\text{kJ mol}^{-1}\ (-333)}{\text{F}} < \underset{(-349)}{\text{Cl}} > \underset{(-325)}{\text{Br}} > \underset{(-296)}{\text{I}}$$

(iv) It is easier to remove electron from $2p$-orbital as compared to $2s$-orbital due to more penetration of s-electrons.

Or

Atomic size and nuclear charge.

57. (i) The element with atomic number 57 belongs to d-block element as the last electron enters the $5d$-orbital against the aufbau principle. This anomalous behaviour can be explained on the basis of greater stability of the xenon (inert gas) core.

After barium $(Z = 56)$, the addition of the next electron (i.e. 57th) should occur in $4f$-orbital in accordance with aufbau principle. This will however, tend to destabilize the xenon core $(Z = 54)$, [Kr] $(4d^{10}\ 4f^0\ 5s^2\ 5p^6\ 5d^0)$ since the $4f$-orbitals lie inside the core.

Therefore, the 57th electron prefers to enter $5d$-orbital which lies outside the xenon core and whose energy is only slightly higher than that of $4f$-orbital. In doing so, the stability conferred on the atom due to xenon core more than compensates the slight instability caused by the addition of one electron to the higher energy $5d$- orbital instead of the lower energy $4f$- orbital.

Thus, the outer electronic configuration of $La(Z = 57)$ is $5d^1\ 6s^2$ rather than the expected $4f^1\ 6s^2$.

(ii) Each period starts with the filling of electrons in a new principal energy shell. Therefore, 6th period starts with the filling of $6s$-orbital and ends when 6 p-orbitals are completely filled.

In between $4f$ and $5d$-orbitals are filled in accordance with aufbau principle. Thus, the outmost electronic configuration of the last element of the p-block in the 6th period is

$6s^2\ 4f^{14}\ 5d^{10}\ 6p^6$ or $4f^{14}\ 5d^{10}\ 6s^2\ 6p^6$.

(iii) The long form of the periodic table contain element with atomic number 1 to 118.

(iv) The fifth period begins with Rb $(Z = 37)$ and ends at Xe.

Thus, the element with $Z = 43$ lies in the 5th period. Since, the 4th period has 18 elements, therefore, the atomic number of the element which lies just above the element with atomic number 43 is $43 - 18 = 25$.

Now, the electronic configuration of element with $Z = 25$ is $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^5\ 4s^2$(i.e. Mn).

Or

Each period ends with a noble gas. The atomic number of noble gases (i.e. group 18 elements) are 2, 10, 18, 36, 54 and 86. Therefore, elements with atomic numbers $35\,(36-1)$, $53\,(54-1)$, and $85\,(86-1)$, lie in a group before noble gases, i.e. halogens (group 17) elements.

Thus, the elements with atomic number 35, 53 and 85 are all belongs to halogens.

58. (i) Assertion is correct but Reason is incorrect. Zinc forms lesser coordination compounds as compared to other elements of 'd'-block.

(ii) Assertion is correct but Reason is incorrect. Be has fully-filled configuration $1s^2, 2s^2$ and that's why removal of electron would require higher energy as the configuration of B is $1s^2, 2s^2, 2p^1$.

(iii) Assertion is incorrect while Reason is correct. Outermost electronic configuration of most electronegative elements is ns^2, np^5.

(iv) Both Assertion and Reason are correct and Reason is the correct explanation of the Assertion.

The magnitude of electron affinity depends on electronic configuration.

Or

Assertion and Reason both are correct but Reason is not the correct explanation of Assertion.

The correct explanation would be : Ionisation enthalpy increases along a period due to increase in effective nuclear charge which cause decreases in atomic size.

59. (i) Mendeleev's arranged elements in horizontal rows and vertical columns in order of their increasing atomic weights in such a way that, the elements with similar properties occupied the same vertical column or group.

Thus, both A and R are correct but R is not the correct explanation of A.

(ii) Both gallium and germanium were unknown at the time Mendeleev published his periodic table.

He left the gap under aluminium and a gap under silicon and called these elements Eka-aluminium and Eka-silicon. Dobereiner arranged elements on the basis of increasing atomic weights.

Thus, A is correct but R is incorrect.

(iii) Elements are arranged in horizontal rows are called periods or Mendeleev's series and having similar outer electronic configuration in their atoms are arranged in vertical columns known as groups or families.

Thus, both (A) and (R) correct and (R) is not the correct explanation of (A).

(iv) (A) is correct but (R) is incorrect statement. The correct (R) statement is as follows :

Sixth period does not involve the filling of all the orbitals of the sixth energy level ($6s, 4f, 5d, 6p$-orbitals are filled).

Or

$2p^6, 3s^2 \longrightarrow$ Belongs to 3rd period

$1s^2, 2s^2 \longrightarrow$ Belongs to 2nd period

Both have ns^2, i.e. same electronic configuration.

Hence, both belongs to different period.

Thus, R is correct but A is incorrect.

60. (i) Assertion and Reason both are correct and Reason is the correct explanation of Assertion.

(ii) Assertion and Reason both are correct and Reason is not correct explanation of Assertion. The correct explanation is : In Al, the first ionisation energy is required for removal of electron from $3s^1$ and in Mg electron is being removed from fully-filled $2s^2$-orbital.

(iii) Assertion is correct but Reason is incorrect. The correct reason is as follows :

F has greater tendency than Cl to attract the shared pair of electrons of a covalent bond.

(iv) Assertion is correct but Reason is incorrect. B shows anomalous behaviour.

Or

Assertion is correct but Reason is incorrect. Carbon is more electronegative as compared to other members of group 14.