CHAPTER > 03

Classification of Elements and Periodicity in Properties

KEY NOTES

- **Periodic classification** of elements can be done on the basis of electronic configuration and is used to examine the periodic trends in physical and chemical properties of the elements.
- In 1800, only 31 elements were known. By 1865, the number of identified elements had more than doubled to 63. At present, 118 elements are known.

Genesis of Periodic Classification

- **Dobereiner Triads** It is a group of three elements with similar physical and chemical properties. In these triads, the atomic mass of the middle element was arithmetic mean of the other two elements. e.g.

Element	Atomic weight	Element	Atomic weight	Element	Atomic weight
Li	7	Ca	40	Cl	35.5
Na	23	Sr	88	Br	80
K	39	Ba	137	I	127

- **Newland's law of octaves** It was an arrangement of elements in the order of their increasing atomic weights in such a manner that every eighth element had properties similar to those of the first element just like the eighth note in an octave of music.
- **Lothar Meyer's atomic volume curve** It represented the classification of elements in the form of a curve between atomic volume and atomic masses. It is observed that, elements with similar properties occupied similar positions on the curve.

Mendeleev's Periodic Law

- It states that "the physical and chemical properties of the elements are the periodic function of their atomic weights".
- In Mendeleev periodic table, there were eight vertical columns (excluding zero group of noble gases) named as groups. These were represented by Roman numerals I to VIII. Each group is divided into sub groups *A* and *B* except the VIII group which had nine elements arranged in three rows as triads, i.e. in the group of three.
- In this table, there were six horizontal rows, named as periods which were further divided into 12 series.
- He ignored the order of atomic weights and placed the elements with similar properties together.
- Mendeleev left the gap for the elements which were unknown at that time. He left the gap under aluminium and a gap under silicon called these elements **Eka-aluminium** and **Eka-silicon**.

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.

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 :

S.No.	Digit	Name	Abbreviation
1.	0	nil	n
2.	1	un	u
3.	2	bi	b
4.	3	tri	t
5.	4	quad	q
6.	5	pent	p
7.	6	hex	h
8.	7	hept	s
9.	8	oct	o
10.	9	enn	e

Electronic Configuration of Elements

- An electron in an atom is characterised by a set of four quantum numbers and the principal quantum number (n) defines the main energy level known as **shell**.
- The distribution of electrons into orbitals of an atom is called its **electronic configuration**.

Electronic Configuration in Periods

- The period indicates the value of n for the outermost or valence shell.
- Number of elements in each period is twice the number of atomic orbitals available in the energy level that is being filled.

Groupwise Electronic Configuration

- The elements in a vertical column of a periodic table constitute a group or family and exhibit similar chemical behaviour.
- Elements are classified into four blocks viz. s, p, d and f-block depending on the type of atomic orbitals that are being filled with electrons.

Classification of Elements

Depending upon the orbital in which last electron enters, the elements are classified as follows :

s-Block Elements

- Group I (alkali metals) and group II (alkaline earth metals) elements belong to this block, their last electron enters in s-orbital.
- General electronic configuration of alkali metals is ns^1 and of alkaline earth metals is ns^2.
- These are all reactive metals with low ionisation enthalpies. They lose the outermost electron(s) and form 1 + or 2 + ions.
- The metallic character and the reactivity of s-block elements increase as we go down the group.
- The compounds of s-block elements with the exception of those of lithium and beryllium are predominantly ionic.

p-Block Elements

- Groups 13th to 18th excluding He, belong to this block. Their last electron enters in p-block.
- General electronic configuration of p-block elements is ns^2 , np^{1-6}.
- s and p-block elements are known as representative elements or main group elements.
- The group 15 members are called pnicogens, group 16 members are called chalcogens and group 17 members are called halogens.

d-Block or Transition Elements

- Elements of group 3rd to 12th in periodic table belong to d-block. Their last electron enters in d-block.
- Two outermost shells of d-block elements are incomplete.
- General electronic configuration of d-block elements is $(n-1)d^{1-10}\,ns^{0-2}$.
- They are all metals. They mostly form 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.
- Transition metals form a bridge between the chemically active metals of s-block elements and the less active elements of group 13 and 14 and, thus these are called "transition elements".

f-Block or Inner-Transition Elements

- General configuration $(n-2)f^{1-14}(n-1)d^{0-1}ns^2$.
- Last electron enters in f-orbital.
- Two series 4f (lanthanoids) and 5f (actinoids) are included in 'f' block elements.
- Also known as rare earth elements.
- **Lanthanoids**, Ce($Z = 58$) to Lu($Z = 71$) and **actinoids**, Th($Z = 90$) to Lr($Z = 103$), are the two rows of elements present at the bottom of the periodic table.

- The chemistry of early actinoids is more complicated than the corresponding lanthanoids due to the large number of oxidation states possible for these actinoid elements.
- Actinoid elements are radioactive.
- The elements after uranium are called **transuranium elements**.

Metals, Non-Metals and Metalloids

- The elements can be broadly divided into metals, non-metals and metalloids.
- Metals comprise more than 78% of all known elements and appear on the left side of the periodic table.
- **Metals** are usually solid at room temperature, have high melting and boiling points, good conductors of heat and electricity, malleable and ductile.
- **Non-metals** are located at the top right hand side of the periodic table.
- Non-metals are usually solids or gases at room temperature have low melting and boiling points, poor conductors of heat and electricity.
- The elements become more metallic as we go down a group. The non-metallic character increases as one goes from left to right across the periodic table.
- The elements which show the properties of both metals and non-metals are termed as **semi-metals or metalloids**.

Periodic Trends in Properties of Elements

The recurrence of properties after regular intervals when they are arranged in the order of increasing atomic number is called **periodicity**.

The properties which show periodicity are called **periodic properties** which are discussed below.

Atomic Radius

- It is referred to both covalent or metallic radius depending upon, whether the element is a non-metal or a metal.
- Atomic radii can be measured by *X*-ray or other spectroscopic methods.
- Atomic radius is used to refer both covalent or metallic radius depending on, whether the element is a non-metal or a metal.
- Atomic radius generally decreases from left to right along a period and increases on moving down the group.
- Being monoatomic, the non-bonded radii of noble gases are very large. Hence, their atomic radii do not get considered.
- The removal of an electron from an atom results in the formation of a cation and gain of an electron leads to an anion.

Ionic Radius

- Ionic radius is used for measuring the distance between cations and anions in ionic crystal.
- The size of cation is smaller than its parent atom, because it has fewer electrons, while its nuclear charge remains same. It is due to greater attraction of electrons to the nucleus, whereas in anions, the net repulsion of the electrons will outweigh the nuclear charge and, thus the ion will expand in size.
- In case of **isoelectronic species**, the cation with greater positive charge will have a smaller radius and anion with the greater negative charge will have the larger radius.

Ionisation Enthalpy

- It represents the energy required to remove an electron from an isolated gaseous atom in its ground state. It is expressed in kJ mol^{-1}.
- Energy is always required to remove electrons from an atom and hence ionisation energy is always positive.
- The second ionisation enthalpy is always greater than the first and in similar way, the third ionisation enthalpy is greater than the second ionisation enthalpy.
- On moving across a period from left to right, the ionisation enthalpy increases and decreases on going down the group.
- The ionisation enthalpy of elements of second group is higher than the corresponding element of thirteen group.

  Also, the ionisation enthalpy of elements of group 15 is higher than that of corresponding elements of group 16.

Electron Gain Enthalpy

- It is the enthalpy change accompanied when an electron is added to a gaseous atom in its ground state to convert it into a negative ion. It is a measure of the ease with which and atom adds an electron to form anion.
- On moving down a group, the electron gain enthalpy become less negative, while on moving from left to right across a period, electron gain enthalpy becomes more negative.
- Electron gain enthalpy is negative as energy is released when an electron is added.
- Group 17 elements have high negative electron gain enthalpy, whereas noble gases have high positive values.

Electronegativity

- A qualitative measure of the ability of an atom of a chemical compound to attract the shared pair of electrons towards itself is called electronegativity.
- Electronegativity generally increases across a period from left to right and decreases with increase in atomic radii on going down a group.
- Non-metallic elements have strong tendency to gain electrons. Therefore, electronegativity is directly related to non-metallic properties of the elements and is inversely related to metallic properties.
- Across a period, **non-metallic character** increases with increase in electronegativity and down the group **non-metallic character** decreases with decrease in electronegativity.

Valence or Oxidation States

- The **valence** of representative elements is usually equal to the number of electrons in the outermost orbitals or equal to eight minus the number of outermost electrons.
- The **oxidation state** of an element in a particular compound can be defined as the charge acquired by its atoms on the basis of electronegative consideration from other atoms in a molecule.
- The behaviour of lithium and beryllium is more similar to with the second element of the following group i.e., magnesium and aluminium. This sort of similarity is commonly referred to as **diagonal relationship** in the periodic properties.
- This similar or **anomalous behaviour** in *'s'* and *p*-block is attributed to their small size, large charge/radius ratio and high electronegativity of elements.
- The maximum covalency of first member of each group in second period is 4 because they have only four valence orbitals (2*s* and 2*p*) available for bonding. Whereas, the second member of the groups have nine valence orbitals. (3*s*, 3*p*, 3*d*) and, hence they can expand their valence shell to accommodate more than four pairs of electrons.
- Also, the first member of *p*-block elements displays greater tendency to form $p\pi - p\pi$ multiple bonds to itself and to other second period elements compared to subsequent members of the same group.

Chemical Reactivity

- Ionisation enthalpy of the extreme left element in a period is the least and the electron gain enthalpy of the element on the extreme right is the highest.
- Thus, the maximum chemical reactivity is at the extreme left (among alkali metals by the loss of an electron) and at the extreme right (among halogens by the gain of an electron) and lowest chemical reactivity at the centre.
- The normal oxide formed by an element on the extreme left is **most basic**. Whereas, that formed by the element on extreme right is the **most acidic**.
- Oxides of elements in the centre are amphoteric, i.e. behave as acidic as well as basic oxides.
- The **reducing nature** of elements increases down the group, whereas **oxidising nature** decreases.

Mastering NCERT

MULTIPLE CHOICE QUESTIONS

TOPIC 1 ~ *Periodic Classification*

1 Periodic classification of elements can be done on the basis of electronic configuration and is used to examine the
(a) periodic trends in physical properties of elements
(b) periodic trends in chemical properties of elements
(c) Both (a) and (b)
(d) None of the above

2 Johann Dobereiner gave the idea of trends among physical and chemical properties of several groups of three elements, the relationship referred to as
(a) law of Triads (b) law of Dobereiner
(c) law of Octaves (d) law of Duet

3 Which of the following is the correct set of elements to Dobereiner's triads?
(a) Li 7, Na 23, K 39 (b) Br 80, Cl 35.5, I 127
(c) Fe 55.85, Ni 58.71, Co 58.93 (d) All of these

4 de-Chancourtois arranged the elements in increasing order of their
(a) atomic numbers (b) atomic weights
(c) atomic radius (d) valency

5 According to Newlands's law of octaves, the properties of Li were similar to
(a) Na (b) K (c) Mg (d) Al

6 Which of the following relationship proposed graphically by Lothar Meyer?
(a) Chemical properties *vs* atomic weight
(b) Physical properties *vs* atomic weight
(c) Physical properties *vs* atomic number
(d) Chemical properties *vs* atomic number

7 Chemical properties of elements, according to Mendeleev, is the periodic function of their
(a) valency (b) atomic number
(c) atomic weight (d) atomic size

8 In Mendeleev's periodic table, iodine with lower atomic weight than that of tellurium was placed alongwith
(a) iron, cobalt and nickel
(b) fluorine, chlorine and bromine
(c) oxygen, sulphur and selenium
(d) carbon, silicon and germanium

9 Mendeleev's left the gap under aluminium and a gap under silicon having atomic weights 68 and 72 respectively. These elements respectively are
(a) Eka-aluminium and Eka-silicon
(b) aluminium and silicon
(c) Eka-germanium and Eka-silicon
(d) Eka-aluminium and Eka-germanium

TOPIC 2 ~ *Modern Periodic Law and the Present form of the Periodic Table*

10 The horizontal rows and the vertical columns in the periodic table are termed as respectively.
(a) periods, groups (b) groups, periods
(c) series, periods (d) family, periods

11 Elements having similar outer shell electronic configuration in their atoms are arranged in
(a) groups (b) vertical columns
(c) families (d) All of these

12 Which of the following in the periodic table corresponds to the highest principal quantum number (n) of the elements?
(a) Group number (b) Period number
(c) Atomic numbe (d) None of these

13 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

14 According to IUPAC, total number of groups and periods in the periodic table respectively are
(a) 16, 9 (b) 18, 7 (c) 18, 9 (d) 13, 7

15 The symbol and name according to the IUPAC system for the element with atomic number = 120, respectively are
(a) Ubn and unbinilium (b) Ubn and unbiunium
(c) Ubn and unnilbium (d) Ubn and unnilium

TOPIC 3 ~ *Electronic Configuration of Elements and their Types : s, p, d and f-Block Elements*

16 Electrons in an atom is characterised by a set of four quantum number and the principal quantum number (n) define (s) the main energy level termed as
(a) shell (b) subshell
(c) orbital (d) None of these

17 Electrons are filled into different orbitals and this distribution of electrons into orbitals of an atoms is termed as
(a) shell
(b) electronic configuration
(c) Both (a) and (b)
(d) None of these

18 The number of elements in second period of the periodic table is
(a) 2 (b) 6 (c) 8 (d) 18

19 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

20 4f inner-transition series and 5f inner-transition series of elements are termed as, respectively
(a) actinoid and 3d- series
(b) lanthanoid and actinoid series
(c) cerium and 3d- series
(d) None of the above

21 3d-transition series of elements starts with Sc and ends with Zn. The electronic configuration of Sc and Zn are respectively.
(a) [Ar] $3d^1 4s^1$ and [Ar] $3d^{10} 4s^1$
(b) [Ar] $3d^1 4s^2$ and [Ar] $3d^{10} 4s^2$
(c) [Ar] $3d^2 4s^1$ and [Ar] $3d^9 4s^3$
(d) [Ar] $3d^3 4s^2$ and [Ar] $3d^8 4s^2$

22 The element $Z = 114$ has been discovered recently. It will belong to which of the following family/group and electronic configuration? ***NEET 2017***
(a) Halogen family, [Rn] $5f^{14}\ 6d^{10}\ 7s^2\ 7p^5$
(b) Carbon family, [Rn] $5f^{14}\ 6d^{10}\ 7s^2\ 7p^2$
(c) Oxygen family, [Rn] $5f^{14}\ 6d^{10}\ 7s^2\ 7p^4$
(d) Nitrogen family, [Rn] $5f^{14}\ 6d^{10}\ 7s^2\ 7p^6$

23 Elements are classified into four blocks as *s*-block, *p*-block, *d*-block and *f*-block on the basis of
(a) atomic number (b) atomic mass
(c) atomic orbitals (d) All of these

24 Out of the four blocks in which periodic table is divided, helium belongs to which block?
(a) *s*-block (b) *p*-block
(c) *d*-block (d) *f*-block

25 ns^1 and ns^2 are outermost electronic configuration of *s*-block elements. They are all reactive metals with
(a) high ionisation enthalpies
(b) low ionisation enthalpies
(c) larger principal quantum number
(d) None of the above

26 Predict the position of an element has 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

27 *s*-block elements are reactive metals. As we go down the group, the reactivity.
(a) Increase (b) Decrease
(c) Remains same (d) None of these

28 The compounds of the *s*-block elements, with the exception of lithium and beryllium are predominantly
(a) ionic (b) covalent
(c) complex (d) Both (a) and (b)

29 The outermost electronic configuration of *p*-block elements varies from ns^2np^1 to
(a) ns^2np^5 (b) ns^2np^4 (c) ns^2np^6 (d) ns^2np^3

30 The noble gases exhibit very low chemical reactivity due to
(a) unavailability of valence electrons
(b) stable configuration
(c) availability of large number of valence electrons
(d) None of the above

31 Which of the following groups of elements have highly negative electron gain enthalpy?
(a) Group-16 (b) Group-17
(c) Group-14 (d) Both (a) and (b)

32 Which of the following properties of *p*-block elements increases as we move from left to right across a period?
(a) Metallic character (b) Non-metallic character
(c) Both (a) and (b) (d) None of these

33 General outer electronic configuration of *d*-block elements is
(a) $(n-1)d^{1-10}ns^3$ (b) $(n+1)d^{1-10}ns^{0-2}$
(c) $(n-1)d^{1-10}ns^{0-2}$ (d) $(n-1)d^0ns^{0-2}$

34 Zn, Cd and Hg do not show most of the properties of
(a) *s*-block elements (b) *d*-block elements
(c) transition elements (d) Both (a) and (c)

35 Outer electronic configuration of *f*-block elements is
(a) $(n+1)f^{1-14}(n-1)d^{0-1}ns^2$
(b) $(n-2)f^{1-14}(n+1)d^{0-1}ns^2$
(c) $(n-2)f^{1-14}(n-1)d^{0-1}ns^2$
(d) None of the above

36 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

37 Arrange the following elements in the decreasing order of metallic characters. Si, Be, Mg, Na and P. Select the correct answer.
(a) Na> Be> Mg> P> Si (b) Na> Mg > Be> P> Si
(c) Na> Be> P> Mg> Si (d) Na> Mg> Be> Si> P

TOPIC 4 ~ *Periodic Trends in Properties of Elements*

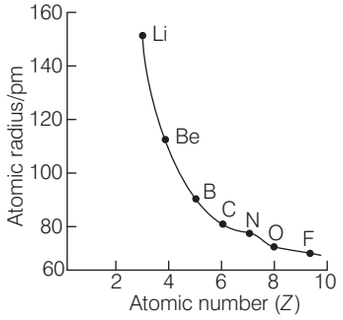
38 If the bond distance in chlorine molecule (Cl_2) is 198 pm, then the atomic radius of chlorine is
(a) 198 pm (b) 49.5 pm (c) 99 pm (d) 24.75 pm

39 Half the internuclear distance separating the metal cores in the metallic crystal is termed as
(a) metallic radius (b) atomic radius
(c) covalent radius (d) ionic radius

40 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

41 The effective nuclear charge experienced by a valence electrons in an atom will be less than the actual charge on the nucleus.
The most appropriate reason for this is,
(a) shielding of the valence electron from the nucleus.
(b) less ionisation enthalpy required to remove valence electron.
(c) core electron are present nearer to nucleus than valence electrons.
(d) Both (a) and (c)

42 Consider the following graph,



The plot has a steep slope from Li to Be but has much less steeper slope from O to F. This is due to the fact that

(a) atomic number increases from Li to F
(b) nuclear charge increases from Li to F
(c) metallic character decreases from Li to F
(d) inter-electronic repulsion in atom increases from Li to F

43 Which of the following radii reflect an increase in size of an atom?

(a) van der Waals' radius (b) Metallic radius
(c) Covalent (non-metallic) radius (d) Both (b) and (c)

44 In the given table, few values are mentioned in the direction from left to right and top to bottom. Which of the following property can be depicted in the table.

Increases ↓	152	111	88	77	74	66
	186	Decreases →				
	231					
	244					
	262					

(a) Atomic number (b) Atomic radius
(c) Ionisation enthalpy (d) Electron gain enthalpy

45 What effect is observed, on the size of an atom when an electron is removed and in another case when an electron is added to the same atom?

(a) Size increases and decreases respectively
(b) Size decreases and increases respectively
(c) Size increases in both cases
(d) Size decreases in both cases

46 Which of the following orders of ionic radius is correctly represented? ***CBSE AIPMT 2015***

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

47 The increasing order of the atomic radii of the following elements is ***JEE Main 2020***

(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) < Aa) < (E)
(d) (B) < (C) < (D) < (A) < (E)

48 Which of the following ions has larger size although they have the same number of electrons?

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

49 The ions with the greater positive charge or negative charge will have the radius, respectively with neutral atom

(a) smaller or larger (b) larger or smaller
(c) remains same (d) None of these

50 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

51 The first ionisation energy (in kJ/mol) of Na, Mg, Al and Si respectively, are : ***JEE Main 2020***

(a) 496, 577, 737, 786 (b) 786, 737, 577, 496
(c) 496, 577, 786, 737 (d) 496, 737, 577, 786

52 For the second period elements the correct increasing order of first ionisation enthalpy is ***NEET (National) 2019***

(a) Li < B < Be < C < O < N < F < Ne
(b) Li < B < Be < C < N < O < F < Ne
(c) Li < Be < B < C < O < N < F < Ne
(d) Li < Be < B < C < N < O < F < Ne

53 Which of the following represents the correct order of increasing first ionisation enthalpy for Ca, Ba, S, Se and Ar? ***JEE Main 2013***

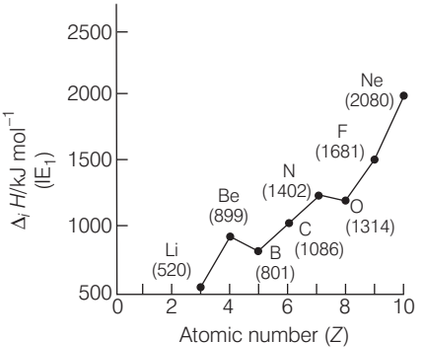
(a) Ca < S < Ba < Se < Ar (b) S < Se < Ca < Ba < Ar
(c) Ba < Ca < Se < S < Ar (d) Ca < Ba < S < Se < Ar

54 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

55 Consider the following graph.



What could be the possible reason for a dip at boron (B) in the above plot?

(a) Size of boron is smaller than Be

(b) $2p$ electrons are more shielded as compared to $2s$ electrons.

(c) The penetration of a $2s$-electron is less than that of a $2p$-electron

(d) Both (a) and (b)

56 The element having greatest difference between its first and second ionisation energy, is

(a) Ca (b) Sc ***JEE Main 2019***

(c) Ba (d) K

57 The first ionisation enthalpy vlaues of third period element, Na, Mg an Si are respectively 496, 737 and 786 kJ mol^{-1}. The first $\Delta_i H$ value for Al will be close to

(a) 760 kJ mol^{-1} (b) 575 kJ mol^{-1}

(c) 950 kJ mol^{-1} (d) 880 kJ mol^{-1}

58 The enthalpy change accompanying in the given reaction,

$$X(g) + e^- \longrightarrow X^-(g) \text{ is defined as}$$

(a) electron gain enthalpy (b) electron loss enthalpy

(c) ionisation enthalpy (d) Both (a) and (c)

59 The first ionisation potential of Na is 5.1 eV. The value of electron gain enthalpy of Na^+ will be ***JEE Main 2013***

(a) –2.55 eV (b) –5.1 eV (c) –10.2 eV (d) +2.55 eV

60 When the first electron gain enthalpy $(\Delta_{e_g} H)$ of oxygen is –141 kJ/mol, its second electron gain enthalpy is ***JEE Main 2019***

(a) a positive value

(b) a more negative value than the first

(c) almost the same as that of the first

(d) negative, but less negative than the first

61 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

62 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

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

(a) electron affinity (b) ionisation enthalpy

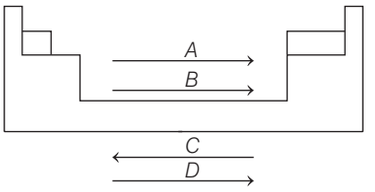
(c) atomic attraction (d) electronegativity

64 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

65 Study the following outline of periodic table and identifying the periodic properties *A, B, C* and *D*, select the correct option.



	A	*B*	*C*	*D*
(a)	Atomic radius	Ionisation enthalpy	Ionic radius	Electronegativity
(b)	Electronegativity	Ionic radius	Atomic radius	Electron gain enthalpy
(c)	Ionic radius	Ionisation enthalpy	Electronegativity	Electron gain enthalpy
(d)	Ionisation enthalpy	Electron gain enthalpy	Atomic radius	Electronegativity

66 In general, the properties that decrease and increase down a group in the periodic table, respectively are

(a) electronegativity and atomic radius ***JEE Main 2019***

(b) electronegativity and electron gain enthalpy

(c) electron gain enthalpy and electronegativity

(d) atomic radius and electronegativity

67 Which of the following properties is inversely related to electronegativity?

(a) Non-metallic properties

(b) Metalloid properties

(c) Ionic properties

(d) Metallic properties

68 Predict the formula of stable compound formed by silicon and bromine.

(a) $SiBr_4$ (b) $SiBr_7$

(c) SiBr (d) $SiBr_2$

69 Oxidation state of oxygen in compounds OF_2 and Na_2O respectively are

(a) +2, – 2 (b) –2, + 2

(c) –2, – 1 (d) +1, – 1

70 The charge acquired by an atom of a particular compound on the basis of electronegative consideration from other atoms in a molecule is termed as

(a) formal charge (b) valency

(c) oxidation state (d) None of these

71 Predict the correct formula of compounds, by the following pair of elements like aluminium and sulphur with the help of oxidation states,

(a) Al_2S_2 (b) Al_2S_3
(c) Al_3S_2 (d) Al_4S_2

72 In which of the following sets of compounds, hydrogen has same oxidation state?

(a) CaH_2, LiH (b) LiH, H_2O
(c) NaH, HCl (d) NaH, H_2O

73 Which of the following types of elements show variable valency?

(a) Transition elements
(b) *s*-block elements
(c) Actinoids
(d) Both (a) and (c)

74 The behaviour of lithium and magnesium is similar to each other. This suggests that both Li and Mg

(a) have diagonal relationship
(b) belong to same group
(c) belong to groups at extreme ends
(d) Both (a) and (b)

75 Boron behaves anomalously with respect to its other group members, because boron has comparatively

(a) small size
(b) large charge to radius ratio
(c) high electronegativity
(d) All of the above

76 $[AlF_6]^{3-}$ exists, while $[BF_6]^{3-}$ does not. Choose the most appropriate reason.

(a) Boron is smaller in size
(b) Boron cannot expand it valence shell
(c) Aluminium shows variable valency
(d) Aluminium is more electropositive

77 The first member of *p*-block elements displays greater ability to form

(a) $p\pi - d\pi$ multiple bonds (b) $p\pi - p\pi$ multiple bonds
(c) single covalent bonds only (d) Both (a) and (b)

78 Which among the following sets of groups consist elements with high chemical reactivity?

(a) Groups-1 and 11 (b) Groups-11 and 17
(c) Groups-1 and 17 (d) Groups-11 and 18

79 Within a group of alkali metals in the periodic table reactivity increases on moving

(a) top to bottom (b) bottom to top
(c) Both (a) and (b) (d) None of these

80 The reactivity of non-metals within a group in the periodic table

(a) increases down the group
(b) decreases down the group
(c) first increase then decrease down the group
(d) first decreases then increases down the group

81 The acidic, basic and amphoteric oxides, respectively are ***JEE Main 2020***

(a) Cl_2O, CaO, P_4O_{10} (b) N_2O_3, Li_2O, Al_2O_3
(c) Na_2O, SO_3, Al_2O_3 (d) MgO, Cl_2O, Al_2O_3,

82 Which of the following compounds is/are amphoteric in nature?

(a) Cl_2O_7 (b) Al_2O_3
(c) As_2O_3 (d) Both (b) and (c)

83 During a chemical reaction with water, alkali metal oxide and halogen oxide behave respectively as

(a) acidic oxide and basic oxide
(b) basic oxide and acidic oxide
(c) Both are natural oxides
(d) Either (a) or (b)

SPECIAL TYPES QUESTIONS

I. Statement Based Questions

84 Which of the following statement is incorrect?

(a) In 1800, only 31 elements were discovered
(b) The recently discovered elements are man-made
(c) At present 110 elements are known
(d) None of the above

85 Which of the following statements is correct?

(a) Dobereiner arranged element by the help of triads methods
(b) Law of triads seemed to work for large number of elements
(c) The properties of Br were in between those of Cl and I
(d) Both (a) and (c)

86 Which of the following statements is correct regarding Newlands's law of Octaves?

(a) The arrangement of the elements in increasing order of their atomic number
(b) Every eighth element had properties similar to the first element
(c) This law is true only for elements upto argon
(d) None of the above

87 Which of the following statements is incorrect?
(a) Mendeleev's arranged elements in horizontal rows and vertical columns
(b) Mendeleev's arranged elements in order of their increasing atomic number
(c) Mendeleev's system of classifying elements was more elaborate than that of Lother Meyer
(d) None of the above

88 Which of the following statements regarding modern periodic law is incorrect?
(a) Henry Moseley observed regularities in the characteristics X-ray spectra of elements
(b) A plot of frequency of X-rays emitted against atomic weight gave a straight line
(c) It is easy to visualize the significance of quantum numbers and electronic configuration in periodicity of element
(d) Electronic configuration of an atom determine the physical and chemical properties

89 Which of the following statements is correct regarding periodic table?
(a) According to modern periodic law, the sixth period is incomplete
(b) Total number of groups are 18
(c) The subsequent periods consist of 2, 8, 8, 16, 32 elements
(d) All of the above

90 Which of following statements regarding the configuration of elements in a periodic table is/are correct?
(a) The period indicates the value of n for the valence shell
(b) The number of elements present in each period is twice the number of atomic orbitals available in the energy level that is being filled
(c) First period starts with filling of the lowest level
(d) All of the above

91 Which of the following statements is incorrect?
(a) The 4th period in the periodic table ends at krypton with the filling up of the 3*p*-orbitals
(b) The 5th period in the periodic table contains the 4*d*-transition series
(c) Starting element of 4*d*-transition series is yttrium
(d) Filling up of the 4*f*-orbitals begins with cerium

92 Which of the following is correct?
(a) group 17 of *p*-block elements has highly negative electron gain enthalpies
(b) groups 17 of *p*-block elements has highly positive electron gain enthalpies
(c) Group -17 elements is known as halogen family
(d) Both (a) and (c)

93 An element A belongs to third period and fifteenth group of the periodic table. Which one of the following is correct regarding the outer electronic configuration of A?
(a) It has completely filled *s*-orbital and *p*-orbital
(b) It has partially filled *d*-orbitals and completely filled *s*-orbital
(c) It has half-filled *d*-orbitals and completely filled *s*-orbitals
(d) It has completely filled *s*-orbital and half-filled *p*-orbitals

94 All of the group-I elements have ns^1 valence shell electronic configuration and the properties of an element have
(a) periodic dependence upon its atomic mass
(b) periodic dependence upon its atomic number
(c) periodic dependence upon its atomic radius
(d) None of the above

95 The elements in a vertical column exhibit similar chemical behaviour. This is because
(a) these elements have the same number of electrons in their outermost orbitals
(b) these elements have the different number of electrons in their outermost orbitals
(c) these elements have no electrons in their outermost orbitals
(d) None of the above

96 When we go down the group, the principal quantum number (n) increases and the valence electrons are farther from the nucleus because
(a) the inner energy levels are filled with electrons
(b) the outer energy levels are filled with electrons
(c) the inner energy levels are not filled with electrons
(d) None of the above

97 Which of the following statements, regarding metals and non-metals is incorrect?
(a) Metals are usually solid at room temperature
(b) Metals have high melting and boiling points
(c) Metals are good conductors of heat and electricity
(d) Non-metals have high melting and boiling points

98 Which of the following is incorrect explanation regarding atomic radius?
(a) Atomic radius changes, when the atom is present in different bonded states
(b) The atomic radii are measured by either X-ray or some spectroscopic methods
(c) Atomic radii classified into covalent radius and non-metallic radius
(d) All of the above

99 Identify the incorrect statement in the following.

NEET 2013

(a) Amongst isoelectronic species, smaller the positive charge on the cation, smaller is the ionic radius

(b) Amongst isoelectronic species, greater the negative charge on the anion, larger is the ionic radius

(c) Atomic radius of the elements increases as one moves down the group of the periodic table

(d) Atomic radius of the elements decreases as one moves across from left to right in the 2nd period of the periodic table

100 Which of the following statement is incorrect?

(a) The removal of the outermost electron requires less energy down a group

(b) The penetration capacity of a 2*s*-electron towords the nucleus is more than that of a 2*p*-electrons in boron

(c) An electron is added to neutral gaseous atom to convert it into positive ion

(d) Boron has a smaller first ionisation enthalpy than beryllium

101 Which of the following statements is/are incorrect?

(a) Electron gain enthalpy becomes more negative with increase in atomic number across a period

(b) Effective nuclear charge increases from left to right across period

(c) Electron gain enthalpy becomes less negative as we go up in a group

(d) All of the above

102 Henry Moseley plotted a graph between $\sqrt{v}$ and Z, where v was the frequency of X-ray emitted by an atom and Z was its atomic number. This graph showed that

(a) the atomic mass is fundamental properties of an element

(b) the atomic number is fundamental property of an element

(c) Both (a) and (b)

(d) The frequency (v) was independent of atomic number

103 The electronic configuration of X, Y and Z elements are given below.

$$X = 1s^2\ 2s^2 2p^6\ 3s^1,$$

$$Y = 1s^2\ 2s^2\ 2p^5$$

$$Z = 1s^2\ 2s^2\ 2p^3$$

Choose the incorrect statements about these elements.

(a) Element X is an alkaline earth metal

(b) Element Z requires less energy to remove an electron than from Y

(c) Element Y is a pnicogens

(d) Both (a) and (b)

104 Consider the following statements :

I. Ionisation energy is the energy required to remove an electron from an isolated gaseous atom from its ground state.

II. Ionisation energy can be either positive or negative.

III. The second ionisation enthalpy will be less than third but greater than first ionisation enthalpy.

Choose the incorrect statements

(a) I and II (b) II and III (c) Only II (d) I, II and III

105 Ionisation enthalpy increases across the second period as we move from Li to F. This is because

(a) shielding of the nuclear charge by the inner core of electrons increases very much from Li to F.

(b) increasing nuclear charge outweighs the shielding.

(c) increase in shielding outweighs the increasing nuclear charge.

(d) Both (a) and (b)

106 Which of the following statement is/are incorrect?

(a) Noble gases have large positive electron gain enthalpy

(b) Electrons gain enthalpy becomes more negative with increase in the atomic number across a period

(c) The effective nuclear charge increases from left to right across a period

(d) The process of adding electrons to the atom always be endothermic

107 Which of the following statement is incorrect?

(a) Non-metals have strong tendency to gain electron

(b) Electronegativity is directly related to non-metallic properties of elements

(c) Electronegativity is inversely proportional to the metallic properties of elements

(d) Increase in electronegativity down a group is accompanied by a decrease in non-metallic properties

108 Which of the following statements are correct regarding electronegativity?

(a) Electronegativity generally decreases across a period in the periodic table from left to right

(b) Electronegativity value increases with the increase in atomic radii down a group

(c) Decrease in electronegativity down a group in the periodic table confirms decreases in non-metallic properties

(d) In a period of the periodic table electronegativity increases with increase in metallic character

109 Consider the following statements :

I. *s*-block elements are found pure in nature.

II. *d*-block elements form coloured ions, exhibit, variable valence and paramagnetism.

III. Lanthanoids contains the elements from Ce ($Z = 58$) to Lu ($Z = 71$)

IV. Actinoids contains the elements from $Th(Z = 90)$ to $Lr(Z = 103)$.

Choose the option with all the correct statements :

(a) I and II (b) III and IV (c) II and III (d) II, III and IV

110 Consider the following statements :

I. Transition elements form a bridge between chemically active metals of *s*-block elements and less active elements of groups 13 and 14.

II. The chemistry of the early actinoids is less complicated than the corresponding lanthanoids.

III. Actinoid elements are radioactive.

IV. The elements after uranium are called transuranium elements.

Choose the option with incorrect statement.

(a) I and III (b) Only II (c) III and IV (d) II and III

111 Consider the following statements :

I. Metals comprise more than 78% of all known elements and appear on the left side of the periodic table.

II. Most non-metallic solids are brittle and are neither malleable nor ductile.

III. The elements become more metallic as we go down a group.

IV. The non-metallic character decreases as one goes from left to right across the periodic table.

Choose the option with all correct statements :

(a) I, II and III (b) II, III and IV

(c) I and II (d) III and IV

112 Consider the following statements :

I. Non-metals are located at the top right hand side of the periodic table.

II. In a horizontal row, the property of elements change from non-metallic character on the left to metallic character on the right.

III. Chemical reactivity tends to be high in group I metals, lower in elements towards the middle of the table and increases to maximum in group 17 elements.

IV. Being monoatomic, the atomic radii of noble gases are very large.

Choose the option with all incorrect statement :

(a) Only II (b) Only IV (c) II and III (d) I and III

113 Consider the following statements :

I. Group 17 elements have very high negative electron gain enthalpies.

II. Noble gases have large positive electron gain enthalpies.

III. Electron gain enthalpies have large negative values towards the upper right of the periodic table.

IV. The electronegativity of any given element is always constant.

Choose the option with all incorrect statements :

(a) I and III (b) II and IV (c) Only IV (d) Only III

114 Consider the following statements :

I. Electronegativity generally increases across a period from left to right.

II. The attraction between the outer electrons and the nucleus increases as the atomic radius decreases in a period.

III. The increase in electronegativities across a period is accompanied by an increase in non-metallic properties.

IV. The valence of representative elements is always equal to the number of electrons in the outermost orbitals.

Choose the option with incorrect statements :

(a) Only IV (b) I, II and IV (c) Only II (d) II and III

115 The maximum chemical reactivity of the elements at the extreme left and at the extreme right of the periodic table is exhibited

(a) by the gain of an electron to form an anion and the loss of an electron to form a cation respectively.

(b) by the loss of an electron to form a cation and the gain of an electron to form an anion respectively.

(c) by the loss of electrons to form cations in both cases.

(d) by the gain of electrons to form an anion in both cases.

II. Assertion and Reason

■ **Directions** (Q.Nos. 116-131) *In the following questions, an Assertion* (A) *is followed by a corresponding Reason* (R). *Use the following keys to choose the appropriate answer.*

(a) Both A and R are correct; R is the correct explanation of A.

(b) Both A and R are correct; and R is not the correct explanation of A.

(c) A is correct; R is incorrect.

(d) R is correct; A is incorrect.

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

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

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

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

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

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

119 **Assertion** (A) The third period in the periodic table contains 18 electrons and not 8 like 2nd period.

Reason (R) In third period, filling of electron starts from $3s^1$ and complete at $3p^6$.

120 **Assertion** (A) Sixth and seventh periods in the periodic table contains 14 elements.

Reason (R) In the periodic table 14 elements each of sixth [from $Z = 58$ to $Z = 71$] and seventh periods [from $Z = 90$ to $Z = 103$] respectively are known as lanthanoids and actinoids.

121 **Assertion** (A) The elements having $1s^2, 2s^2, 2p^6, 3s^2$ and $1s^2, 2s^2$ configuration belong to same period.

Reason (R) Both have same outermost electronic configuration.

122 **Assertion** (A) Noble gases are highly reactive.

Reason (R) Noble gases have stable outer electronic configuration.

123 **Assertion** (A) Element with electronic configuration $[Ar]4s^2 3d^5$ is a *d*- block element.

Reason (R) The last electron enters the *d*-orbital.

124 **Assertion** (A) The atomic and ionic radii generally decrease towards right in a period.

Reason (R) The ionisation enthalpy increases on moving towards left in a period.

125 **Assertion** (A) Boron has a smaller first ionisation enthalpy than beryllium.

Reason (R) 2*p*-electron of boron is more shielded from the nucleus by the inner core of electrons.

126 **Assertion** (A) Helium has the highest first ionisation enthalpy in the periodic table.

Reason (R) Ionisation enthalpy decreases from top to bottom in a group.

127 **Assertion** (A) Na^+ and Al^{3+} are isoelectronic species.

Reason (R) Na belongs to *s*-block, while Al belongs to *p*-block.

128 **Assertion** (A) Na^+ and Al^{3+} are isoelectronic but the ionic radii of Al^{3+} is smaller than Na^+

Reason (R) The nuclear attraction on the outermost shell electrons of Al^{3+} is greater than that of Na^+.

129 **Assertion** (A) Be and Al show some similar properties.

Reason (R) The metallic radius of Be is less than the metallic radius of Al.

130 **Assertion** (A) Electron gain enthalpy becomes less negative as we go down a group. ***AIIMS 2018***

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

131 **Assertion** (A) In a group while going from top to bottom, oxidising nature of element decreases.

Reason (R) The tendency to accept electrons decreases, on moving down the group.

III. Matching Type Questions

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

Column I (Element discovered year)	**Column II** (The number of elements discovered)
A. 1800	1. 118
B. 1865	2. 63
C. At present	3. 31

Codes

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

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

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

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

Column I (Element types)		Column II (General electronic configuration)
A. Inert gas elements	1.	$(n-1)d^{1-10}\ ns^{1-2}$
B. Transition elements	2.	ns^2 to ns^2np^6
C. Inner-transition elements	3.	$(n-2)f^{1-14}(n-1)s^2p^6d^{0-1}\ ns^2$

Codes

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

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

Column I		Column II
A. 3*d*-transition series	1.	Cerium ($Z = 58$)
B. 4*d*-transition series	2.	Actinium ($Z = 89$)
C. 4*f*-inner transition series	3.	Zinc ($Z = 30$)
D. 5*f*-inner transition series	4.	Yttrium ($Z = 39$)

Codes

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

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

Column I (Atomic number)		Column II (Position in the periodic table)
A. 52	1.	*s*-block
B. 56	2.	*p*-block
C. 57	3.	*d*-block
D. 60	4.	*f*-block

Codes

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

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

Column I		Column II
A. Inner-transition elements	1.	Representative elements
B. *s* and *p*-block elements.	2.	*f*-block
C. Elements of 3rd period	3.	Typical elements

Codes

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

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

Column I (Order)		Column II (Properties)
A. $Li^+ < Al^{3+} < Mg^{2+} < K^+$	1.	EA (Electron affinity)
B. $Li^+ > Al^{3+} > Mg^{2+} > K^+$	2.	Ionic radii
C. Cl > F > Br > I	3.	EN (Electronegativity)
D. F > Cl > Br > I	4.	ENC (Effective nuclear charge)

Codes

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

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

Column I		Column II
A. F	1.	Maximum electron affinity
B. Cl	2.	Maximum electronegativity
C. Br	3.	Exists as X_2 in liquid state
D. I	4.	X_2 sublimates on heating.

Codes

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

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

NCERT & NCERT Exemplar

MULTIPLE CHOICE QUESTIONS

NCERT

142 Which important property did Mendeleev use to classify the elements in his periodic table?
(a) Atomic weight (b) Atomic number
(c) Melting point (d) None of these

143 In the modern periodic table, the period indicates the value of
(a) atomic number
(b) atomic mass
(c) principal quantum number
(d) azimuthal quantum number

144 Which of the following statements related to the modern periodic table is incorrect?
(a) The *p*-block has 6 columns, because a maximum of 6 electrons can occupy all the orbitals in a *p*-shell
(b) The *d*-block has 8 columns because a maximum of 8 electrons can occupy all the orbitals in a *d*-subshell
(c) Each block contains a number of columns equal to the number of electrons that can occupy that subshell
(d) The block indicates value of azimuthal quantum number (l) for the last subshell that received electrons in building up the electronic configuration

145 In terms of period and group, where would you locate the element with, $Z = 114$?
(a) Period-5, group- 6 (b) Period-7, group-14
(c) Period-5, group-10 (d) Period-3, group-13

146 Mark the atomic number of the element present in the third period and seventeenth group of the periodic table.
(a) 17 (b) 18 (c) 19 (d) 20

147 Assign the position of the element having outer electronic configuration ns^2np^4 for $n = 3$
(a) third period, 16th group (b) second period, 15th group
(c) third period, 14th group (d) fourth period, 15th group

148 The elements in the same group have similar physical and chemical properties because of
(a) similar electronic configuration
(b) dissimilar electronic configuration
(c) similar atomic size
(d) None of the above

149 Considering the elements B, Al, Mg and K, the correct decreasing order of their metallic character is
(a) B > Al > Mg > K (b) Al > Mg > B > K
(c) Mg > Al > K > B (d) K > Mg > Al > B

150 Considering the elements B, C, N, F and Si, the correct order of their non-metallic character is
(a) B > C > Si > N > F (b) Si > C > B > N > F
(c) F > N > C > B > Si (d) F > N > C > Si > B

151 Consider the following species,

$$N^{3-},\ O^{2-},\ F^-,\ Na^+,\ Mg^{2+} \text{ and } Al^{3+}$$

Arrange them in the order of their increasing ionic radii.
(a) $Mg^{2+} < Al^{3+} < N^{3-} < Na^+ < F^- < O^{2-}$
(b) $Al^{3+} < Mg^{2+} < Na^+ < F^- < O^{2-} < N^{3-}$
(c) $Al^{3+} < Mg^{2+} < N^{3-} < Na^+ < F^- < O^{2-}$
(d) $N^{3-} < O^{2-} < F^- < Na^+ < Mg^{2+} < Al^{3+}$

152 The size of isoelectronic species; F^-, Ne and Na^+ is affected by
(a) nuclear charge (Z)
(b) valence principal quantum number (n)
(c) electron-electron interaction in the outer orbitals
(d) None of the factors because their size is the same

153 Which one of the following statements is incorrect in relation to ionisation enthalpy?
(a) Ionisation enthalpy increases for each successive electron
(b) The greatest increase in ionisation enthalpy is experienced on removal of electron from core noble gas configuration
(c) End of valence electrons is marked by a big jump in ionisation enthalpy
(d) Removal of electron from orbitals bearing lower n value is easier than from orbital having higher n value

154 Anything that influences the valence electrons will affect the chemistry of the element. Which one of the following factors does not affect the valence shell?
(a) Valence principal quantum number (n)
(b) Nuclear charge (Z)
(c) Nuclear mass
(d) Number of core electrons

155 Considering the elements F, Cl, O and N, the correct order of their chemical reactivity in terms of oxidising property is
(a) F > Cl > O > N (b) F > O > Cl > N
(c) Cl > F > O > N (d) O > F > N > Cl

NCERT Exemplar

156 The statement that is incorrect for periodic classification of elements is

(a) the properties of elements are periodic function of their atomic numbers

(b) non-metallic elements are less in number than metallic elements

(c) for transition elements, the 3*d*-orbitals are filled with electrons after 3*p*-orbitals and before 4*s*-orbitals

(d) the first ionisation enthalpies of elements generally increase with increase in atomic number as we go along a period

157 The period number in the long form of the periodic table is equal to

(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

158 The elements in which electrons are progressively filled in 4*f*-orbital are called

(a) actinoids (b) transition elements

(c) lanthanoids (d) halogens

159 Which of the following is not an actinoid?

(a) Cerium ($Z = 96$) (b) Californium ($Z = 98$)

(c) Uranium ($Z = 92$) (d) Terbium ($Z = 65$)

160 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) $[Xe]\,4f^8\,5d^6\,6s^2$

161 The order of screening effect of electrons of *s, p, d* and *f* orbitals of a given shell of an atom on its outer shell electrons is

(a) $s > p > d > f$ (b) $f > d > p > s$

(c) $p < d < s > f$ (d) $f > p > s > d$

162 Which of the following is the correct order of size of the given species?

(a) $I > I^- > I^+$ (b) $I^+ > I^- > I$

(c) $I > I^+ > I^-$ (d) $I^- > I > I^+$

163 Consider the isoelectronic species, Na^+, Mg^{2+}, F^- and O^{2-}. The correct order of increasing length of their radii is

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

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

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

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

164 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

165 Among halogens, the correct order of amount of energy released in electron gain enthalpy is

(a) F > Cl > Br > I (b) F < Cl < Br < I

(c) F < Cl > Br > I (d) F < Cl < Br < I

166 Electronic configuration of four elements *A*, *B*, *C*, and *D* are given below.

A. $1s^2\,2s^2\,2p^6$ B. $1s^2\,2s^2\,2p^4$

C. $1s^2\,2s^2\,2p^6\,3s^1$ D. $1s^2\,2s^2\,2p^5$

Which of the following is the correct order of increasing tendency to gain electron?

(a) $A < C < B < D$ (b) $A < B < C < D$

(c) $D < B < C < A$ (d) $D < A < B < C$

167 The formation of oxide ion $O^{2-}(g)$, from oxygen atom requires first an exothermic and then an endothermic step as shown below.

$$O(g) + e^- \longrightarrow O^-(g);\ \Delta H^- = -141\ \text{kJ mol}^{-1}$$

$$O^-(g) + e^- \longrightarrow O^2(g);\ \Delta H^- = +780\ \text{kJ mol}^{-1}$$

Thus, process of formation of O^{2-} in gas phase is unfavourable even though O^{2-} is isoelectronic with neon. It is due to the fact that

(a) oxygen is more electronegative

(b) addition of electron in oxygen results in larger size of the ion

(c) electron repulsion outweighs the stability gained by achieving noble gas configuration

(d) O^- ion has comparatively smaller size than O-atom

168 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 value.

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

Choose the correct option.

Codes

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

Answers

› Mastering NCERT with MCQs

1 (c)	2 (a)	3 (a)	4 (b)	5 (a)	6 (b)	7 (c)	8 (b)	9 (a)	10 (a)
11 (d)	12 (b)	13 (a)	14 (b)	15 (a)	16 (c)	17 (b)	18 (c)	19 (d)	20 (b)
21 (b)	22 (b)	23 (c)	24 (b)	25 (b)	26 (a)	27 (a)	28 (a)	29 (c)	30 (b)
31 (d)	32 (b)	33 (c)	34 (c)	35 (c)	36 (c)	37 (d)	38 (c)	39 (a)	40 (a)
41 (a)	42 (d)	43 (a)	44 (b)	45 (b)	46 (a)	47 (a)	48 (d)	49 (a)	50 (b)
51 (a)	52 (a)	53 (c)	54 (c)	55 (b)	56 (d)	57 (b)	58 (a)	59 (b)	60 (a)
61 (b)	62 (d)	63 (d)	64 (d)	65 (d)	66 (a)	67 (d)	68 (a)	69 (a)	70 (c)
71 (b)	72 (a)	73 (d)	74 (a)	75 (d)	76 (b)	77 (b)	78 (c)	79 (a)	80 (b)
81 (b)	82 (d)	83 (b)							

› Special Types Questions

84 (c)	85 (d)	86 (b)	87 (b)	88 (b)	89 (b)	90 (d)	91 (a)	92 (d)	93 (d)
94 (b)	95 (a)	96 (a)	97 (d)	98 (c)	99 (a)	100 (c)	101 (c)	102 (b)	103 (d)
104 (c)	105 (b)	106 (d)	107 (d)	108 (c)	109 (d)	110 (b)	111 (a)	112 (a)	113 (c)
114 (a)	115 (b)	116 (b)	117 (c)	118 (b)	119 (d)	120 (d)	121 (d)	122 (d)	123 (a)
124 (c)	125 (a)	126 (b)	127 (b)	128 (a)	129 (b)	130 (a)	131 (a)	132 (d)	133 (b)
134 (b)	135 (b)	136 (d)	137 (a)	138 (b)	139 (b)	140 (b)	141 (d)		

› NCERT & NCERT Exemplar Questions

142 (a)	143 (c)	144 (b)	145 (b)	146 (a)	147 (a)	148 (a)	149 (d)	150 (c)	151 (b)
152 (a)	153 (d)	154 (c)	155 (b)	156 (c)	157 (c)	158 (c)	159 (d)	160 (c)	161 (a)
162 (d)	163 (b)	164 (a)	165 (c)	166 (a)	167 (c)	168 (a)			

3 (*a*) In option (a), middle atom (Na) of the triads has an atomic weight equal to the average of the atomic weights of the other two elements (i.e. Li and K).

$$\begin{array}{ccc} \text{Li} & \text{Na} & \text{K} \\ \downarrow & \downarrow & \downarrow \\ 7 & 23 & 39 \end{array}$$

$$\frac{39+7}{2} = \frac{46}{2} = 23$$

4 (*b*) de-Chancourtois in 1862 arranged the known elements in the order of increasing atomic weights and made a cylindrical table of elements to display the periodic recurrence of properties.

5 (*a*) According to Newland's law of octaves, every eighth element properties are similar to first element.

	1	2	3	4	5	6	7
Element	Li	Be	B	C	N	O	F
At. wt.	7	9	11	12	14	16	19
Element	Na	Mg	Al	Si	P	S	Cl
At. wt.	23	24	27	29	31	32	35.5
Element	K	Ca					
At. wt.	39	40					

Thus, properties of Li is similar to Na.

6 (*b*) Lothar Meyer plotted the physical properties such as atomic volume, melting point and boiling point against atomic weight and obtained a periodically repeated pattern. Thus, the graph shows the relationship of physical properties *vs* atomic weight.

8 (*b*) Iodine with lower atomic weight than that of tellurium was placed in Group VII alongwith fluorine, chlorine, bromine because of similarities in properties.

11 (*d*) Similar outer shell configuration in their atoms are arranged in vertical columns called groups or families.

13 (*a*) 14 elements of 6th period are called lanthanoids and those of 7th period are termed as actinoids.

14 (*b*) According to the recommendation of IUPAC, the groups are numbered from 1 to 18, while the periods are numbered from 1 to 7, i.e. total number of groups is 18 and total number of periods is 7.

15 (*a*) For atomic number (Z) = 120,

the IUPAC name of element = Unbinilium

and symbol = Ubn

18 (*c*) The number of elements in second period of the periodic table is 8 i.e. from lithium (Li) to neon (Ne).

20 (*b*) 4*f* inner-transition series is termed as lanthanoid series, whereas 5*f* inner-transition series is termed as actinoid series.

21 (*b*) Before the 4 *p*-orbital is filled, filling-up of 3*d*-orbitals becomes energetically favourable and we come across 3*d* transition series of elements. This starts from scandium ($Z = 21$) which has electronic configuration = $[Ar]3d^1 4s^2$ and end at zinc ($Z = 30$) with electronic configuration = $[Ar]3d^{10}, 4s^2$

22 (*b*) The element with atomic number, $Z = 114$ is flerovium (Fl). It is a super heavy artificial chemical element. In the periodic table, it is a transactinide element in the *p*-block. It is a member of the 7th period and is the heaviest known member of the carbon family.

Electronic configuration for $Z = 114$ is

$$[Rn]_{86}\ 5f^{14}, 6d^{10}, 7s^2, 7p^2$$

As, the electronic configuration of outer shell is $7s^2, 7p^2$. So, it belongs to carbon family.

23 (*c*) Elements are classified into four blocks, as *s*-block, *p*-block, *d*-block and *f*-block on the basis of atomic orbitals (*viz*. *s*, *p*, *d* and *f*).

24 (*b*) Helium belongs to the *p*-block, inspite of differentiating electron occupy 1*s*-orbital. Helium has a completely filled valence shell ($1s^2$) and as a result, it exhibits characteristic properties of other noble gases.

25 (*b*) ns^1 and ns^2 are outermost electronic configuration of *s*-block elements.

$ns^1 \longrightarrow$ alkali metals

$ns^2 \longrightarrow$ alkaline earth metals

They are all reactive metals with low ionisation enthalpies.

26 (*a*) As $n = 4$, hence element lies in 4th period.

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

So, the given element position is period 4 and group 6.

27 (*a*) *s*-block elements are reactive metals because they lose the outermost electrons readily to form +1 or +2 ion. The reactivity increases as we go down the group because ionisation enthalpy decreases down the group.

28 (*a*) With the exception of lithium and beryllium compounds of *s*-block elements are predominantly ionic.

30 (*b*) The noble gases are completely filled by electrons and it is very difficult to alter this stable electronic configuration, hence, they show low chemical reactivity.

31 (*d*) The halogens (group 17) and the chalcogens (group-16) are two groups of elements having highly negative electron gain enthalpies.

32 (*b*) The non-metallic character of *p*-block elements increases as we move from left to right across a period and metallic character increases as we move down the group.

33 (*c*) *d*-block elements are elements of group 3 to 12 in the centre of the periodic table.

So, general outer electronic configuration is $(n-1)d^{1-10}ns^{0-2}$.

34 (*c*) Zn and Cd have the electronic configuration $(n-1)d^{10}\ ns^2$ but Hg do not show properties of transition elements.

36 (*c*) 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.

37 (*d*) Down the group metallic character increases, while in period from left to right metallic character decreases, but non-metallic character increases.

So, the correct order is

$$Na > Mg > Be > Si > P$$

Alkali metals have more metallic character than other groups.

38 (*c*) Atomic radius of Cl atom $= \dfrac{\text{Bond distance in } Cl_2}{2}$

$$= \frac{198}{2} = 99 \text{ pm}$$

40 (*a*) Internuclear distance between Cu-atoms in solid copper = 256 pm.

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

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

41 (*a*) The effective nuclear charge experienced by valence electrons in an atom will be less than the actual charge on the nucleus. This is because of shielding or screening of the valence electron from the nucleus by the intervening core electrons.

42 (*d*) As we move left to right in a period, the number of electron in outer shell increases with increase in atomic number. This results in increase in inter-electronic repulsions in the outermost shell from Li to F.

Therefore, decrease in radius from O to F is not as much as that is in case of from Li to Be.

44 (*b*) Atomic radius is depicted in the table, as it decreases along the period and increases down the group.

45 (*b*) Size of an atom decreases when an electron is removed from it due to increased nucleus charge. While, size of an atom increases with addition of an extra electron (formation of anion) due to increased repulsion among electrons.

46 (*a*) The correct order of ionic radius is represented in option (a).

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

Radius of a cation is always smaller than that of a neutral atom due to increase in effective nuclear charge, whereas the radius of anion is always greater than cation due to decrease in effective nuclear charge.

Hence, the given order is correct.

(b) $Na^+ > F^- > O^{2-}$

The given species are isoelectronic as they contain same number of electrons. For isoelectronic species,

$$\text{ionic radius} \propto \frac{1}{\text{nuclear charge}}$$

Ion	Na^+	F^-	O^{2-}
Nuclear charge	+11	+9	+8

Hence, the correct order of ionic radius is

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

For option (c), the correct order is same as for option (b).

(d) Al^{3+} Mg^{2+} N^{3-}

are also isoelectronic species.

Hence, the correct order is

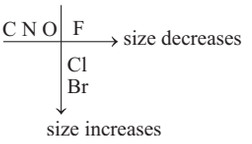
$$N^{3-} > Mg^{2+} > Al^{3+}$$

47 (*a*) Atomic radius generally decreases as we compare elements in a period from left to right,

$\therefore$ $C > O > F$

but elements present in next period are larger in size,

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



So, the correct increasing order of the atomic radii

$$C < B < A < D < E$$

48 (*d*) All the ions have 10 electrons and, thus are isoelectronic species. Size of O^{2-} is largest among $F^-, Na^+, Mg^{2+}, O^{2-}$ ions. This is due to the fact that, addition of one or more electrons would result in increased repulsion among the electrons and a decrease in effective nuclear charge.

49 (*a*) The ion with the greater positive charge will have a smaller radius because of the greater attraction on the electrons due to the nucleus and ions with the greater negative charge will have large radius due to net repulsion of electrons.

50 (*b*) 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.

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

51 (*d*) The first ionisation energy (in kJ/mol) of Na, Mg, Al and Si respectively are

496, 737, 577, 786

All four elements belong to the same period (3rd period) and the general trend in a period from left to right is increase in first ionisation energy, because of increase in nuclear charge and decrease in radii.

Therefore, the expected order of first ionisation enthalpies of given elements should be

$$Na < Mg < Al < Si$$

But first ionisation energies of Mg and Al show anomalous order because Mg has stable $[Ne]3s^2$ configuration and, therefore higher ionisation energy than expected, whereas Al has $[Ne]3s^2 3p^1$ configuration, which on ionisation becomes stable $[Ne]3s^2$.

$\therefore$ Its ionisation energy is less than expected.

52 (*a*) The increasing nuclear charge outweighs the shielding effect across a period. As a result, the outermost electrons are held more firmly, hence ionisation enthalpy (IE) increases across a period as :

$$Li < B < Be < C < O < N < F < Ne$$

Exceptions (i) IE of boron (B) is less than IE of beryllium (Be). It is due to the presence of fully-filled 2*s*-orbitals in Be.

(ii) IE of oxygen (O) is less than that of nitrogen (N). It is because of the presence of half-filled *p*-orbitals in N which provides extra stability.

53 (*c*) Ionisation energy increases along a period from left to right and decreases down a group. The position of given elements in the periodic table is as,

Group 2	Group 16	Group 18
Ca	S	Ar
Ba	Se	

Thus, the order of increasing ΔH_{IE_I} is

$$Ba < Ca < Se < S < Ar$$

54 (*c*) 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.

55 (*b*) In boron (B), the electron is removed from *p*-orbital. The 2*p*-electrons of boron is more shielded from the nucleus by inner core of electrons than the 2*s*-electrons. Therefore, it is easier to remove the 2*p*-electrons from boron compared to the removal of a 2*s*-electron from beryllium. Also, removal of one 2*p*-electron from boron leads to a comparatively stable configuration of $2s^2$, where the two electrons are paired.

Hence, the first ionisation energy of boron (B) is lower than both Be and C.

56 (*d*) The electronic configuration of given elements are as follows :

$K(19) = 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1$

$Mg(12) = 1s^2\ 2s^2\ 2p^6\ 3s^2$

$Sr(38) = 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6\ 5s^2$

$Sc(21) = 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^1$

First ionisation enthalpy (I.E.) of K is lowest among the given options. Here, the energy required to remove an electron from $4s^1$ is least as only one electron is present in the outermost shell. I.E. (I) is comparatively high for Mg and Sr and two electrons (fully-filled) are placed in *s*-orbitals. Second ionisation enthalpy of K is highest among the given options.

Now, removal of an electron occur from p^6 (fully-filled). So, high energy is required to remove the electron. From the above discussion, it can be concluded that $(I.E_2 - I.E_1)$ value is maximum for K (potassium).

57 (*b*) First $\Delta_i H$ value for Al will be more close to 575 kJ mol^{-1}. The value for Al should be lower than that of Mg because of effective shielding of 3*p*-electrons from the nucleus by 3*s*-electrons.

58 (*a*) The enthalpy change accompanying in the given reaction is defined as electron gain enthalpy.

It is defined as the enthalpy change.

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

59 (*b*) $Na \longrightarrow Na^+ + e^-$ [First IE]

$Na^+ + e^- \longrightarrow Na$ [Electron gain enthalpy]

Electron gain enthalpy of Na^+ is reverse of ionisation enthalpy because reaction is reverse, so

$$\Delta H(\text{eg}) = -5.1 \text{ eV}$$

60 (*a*) As given, the first electron gain enthalpy of oxygen can be shown as,

$O(g) + e^- \longrightarrow O^-(g), \Delta e_g H_1 = -141 \text{ kJ/mol}$

The expression of second electron gain enthalpy of oxygen will be,

$O^-(g) + e^- \longrightarrow O^{2-}(g), \Delta e_g H_2 = +\text{ ve}$

$\Delta e_g H_2$ of oxygen is positive, i.e. endothermic, because a strong electrostatic repulsion will be observed between highy negative O^- and the incoming electron (e^-). A very high amount of energy will be consumed (endothermic) by the system to overcome the electrostatic repulsion.

61 (*c*) 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

	F	<	Cl	>	Br	>	I
kJ mol^{-1}	(−333)		(−349)		(−325)		(−296)

62 (*d*) 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 2*p* orbital leads to greater repulsion than adding an electron to the larger 3*p*-orbital.

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

63 (*d*) A qualitative measure of the ability of an atom in a chemical compound to attract shared electrons to itself is called electronegativity.

64 (*d*) Electronegativity increases on moving from left to right in a period.

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

$$F > O > N$$

65 (*d*) Ionisation enthalpy (*A*), electron gain enthalpy (*B*), atomic radius (*C*) and electronegativity (*D*) increases across a period from left to right, while atomic radius (*C*) decreases.

66 (*a*) The summary of variation of periodic properties is given in table below :

S.No.	Periodic property	Variation	
		Along a period	Along a group
1.	Atomic radius	Decreases	Increases
2.	Electron gain enthalpy	Increases	Decreases
3.	Electronegativity	Increases	Decreases

Thus, electronegativity decreases and atomic radius increases down a group in the periodic table.

67 (*d*) Electronegativity (EN) $\propto \dfrac{1}{\text{metallic properties}}$

EN decreases down a group is accompanied by a increase in metallic properties or decrease in non-metallic properties of elements.

69 (*a*) OF_2, here EN of fluorine is more than oxygen.

So, oxidation state of fluorine $= -1$

and oxidation state of oxygen $= +2$

In Na_2O, oxygen has more electronegative value than sodium,

So, oxidation state of oxygen $= -2$

and oxidation state of Na $= +1$

71 (*b*) Oxidation state of aluminium (Al) $= +3$.

Oxidation state of sulphur $= -2$ with respect to aluminium, hence correct formula is $= Al_2S_3$.

72 (*a*) In CaH_2, LiH and NaH, the oxidation state of H is -1, while in H_2O and HCl, the oxidation state of H is $+1$.

Thus, same oxidation state of H is in CaH_2 and LiH.

74 (*a*) The behaviour of lithium is more similar to that of magnesium, which refers to a diagonal relationship between the two as both belongs to adjacent groups and are diagonally placed.

76 (*b*) The most appropriate reason is that, boron cannot expand its valence shell and its maximum valency is limited to 4, while Al can expand its valence shell and hence can form $[AlF_6]^{3-}$.

77 (*b*) The first member of *p*-block elements displays greater ability to form $p\pi - p\pi$ multiple bonds to itself (e.g. C = C, C ≡ C, N = N, N ≡ N) and to other second period elements (e.g., C = O, C = N, C ≡ N N = O) compared to subsequent members of the same group.

78 (*c*) Groups 1 and 17 consist highly reactive elements. They tend to lose and gain electron(s) respectively to achieve inert gas configuration.

79 (*a*) Within a group of representative metals, (alkali metals) reactivity increases on moving down the group, i.e. top to bottom. It is because, the elements have high tendency to lose an electron to form cation and this tendency increases on moving down the group.

80 (*b*) Within a group of non-metals, reactivity decreases down the group. This is because, they have high tendency to accept an electron to form an anion and this tendency decreases on moving down the group.

81 (*b*) The acidic, basic and amphoteric oxides, respectively are N_2O_3, Li_2O and Al_2O_3. The normal oxides of the elements present on extreme left of periodic table are most acidic (Li_2O) as they form strong base when dissolved in water and oxides of the elements present in extreme right are acidic (N_2O_3). The amphoteric oxides show both the acidic and basic character (Al_2O_3).

82 (*d*) Al_2O_3 and As_2O_3 are amphoteric in nature. These oxides behave as acidic with bases and basic with acids.

83 (*b*) During a chemical reaction with water, alkali metal oxide and halogen oxide behave respectively as basic oxide and acidic oxides. Reactions are as follows :

$$Na_2O + 2H_2O \longrightarrow \underset{\text{Basic nature}}{2NaO} + 2H_2O$$

$$2Cl_2O_7 + 2H_2O \longrightarrow \underset{\text{Acidic nature}}{4HCl} + 8O_2$$

84 (*c*) Statement (c) is incorrect.
It's correct form is as follows :
At present 118 elements are known.
Rest other statements are correct.

85 (*d*) Statements (a) and (c) are correct, while the statement (b) is incorrect.
It's correct form is as follows :
Law of triads, seemed to work only for few elements.

86 (*b*) Statement (b) is correct, while the other statements are incorrect. Corrected form are as follows :
John Alexander Newlands in 1865 profounded the law of octaves.
(a) He arranged the elements in the increasing order of their atomic weights.
(c) Newland's law of octaves seemed to be true only for elements upto calcium.

87 (*b*) Statement (b) is incorrect.
It's correct form is as follows :
Mendeleev arranged elements in horizontal rows and vertical columns of table in the order of their increasing atomic weights in such a way that the elements with similar properties occupied the same vertical column or group.
Rest other statements are correct.

88 (*b*) Statement (b) is incorrect.
It's correct form is as follows :
A plot of $\sqrt{v}$ (where v is frequency of X-rays emitted) against atomic number (Z) gave a straight line.
Rest other statements are correct.

89 (*b*) Statement (b) is correct, while the other statements are incorrect.
Corrected form are as follows :
(a) According to modern periodic law, the seventh period is incomplete.
(c) Subsequent periods consist of 2, 8, 8, 18, 18 and 32 elements.

91 (*a*) Statement (a) is incorrect.
It's correct form is as follows :
The 4th period in the periodic table ends at krypton with the filling up of the 4*p*-orbitals. Altogether, 18 elements are present in this fourth period.
Rest other statements are correct.

92 (*d*) Statements (a) and (c) are correct, while the other statement (b) is incorrect.
It's correct form is as follows :
17th group has highly negative electron gain enthalpies and add stable noble gas configuration by accepting electrons.

93 (*d*) The element A can be phosphorus (P) and its electronic configuration is

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

So, element 'A' has completely filled *s*-orbital and half-filled *p*-orbitals.
Thus, statement (d) is correct.

95 (*a*) The elements in a vertical column of the periodic table constitute a group or family and exhibit similar chemical behaviour, this similarity arises because these elements have the same number and same distribution of electrons in their outermost orbitals.
Thus, the statement (a) is correct.

96 (*a*) When we move down the group, the principal quantum number (n) increases and the valence electrons move farther from nucleus. This happens because the inner energy levels are filled with electrons.
Thus, the statement (a) is correct.

97 (*d*) Statement (d) is incorrect.
It's correct form is as follows :
Non-metals are usually solid or gases at room temperature with low melting and boiling points (boron and carbon are exceptions).
Rest other statements are correct.

98 (*c*) Statement (c) is incorrect.
It's correct form is as follows :
Atomic radii classified into covalent radius and metallic radius.
Rest other statements are correct.

99 (*a*) Statement (a) is incorrect.
It's correct form is as follows :
Amongst isoelectronic species, smaller the positive charge on the cation, larger is the ionic radius.
Rest other statements are correct.

100 (*c*) Statement (c) is incorrect.
It's correct form is as follows :
An electron is added to neutral gaseous atom to convert it into negative ion.
Rest other statements are correct.

101 (*c*) Statement (c) is incorrect.
It's correct form is as follows :
Generally, electron gain enthalpy becomes more negative as we go up in a group. Because the size of the atom decreases and the added electron would be nearer to the nucleus.
Rest other statements are correct.

102 (*b*) Henry Moseley ploted a graph of $\sqrt{v}$ *vs* Z and showed that the atomic number is more fundamental property of an element than its atomic mass.

103 (*d*) Statements (a) and (b) are incorrect.
It's correct form are as follows :
(a) Element X is an alkali metal as it's valence shell electronic configuration is $3s^1$.
(b) Element Z requires more energy to remove an electron than from Y because it has stable half-filled configuration.
Rest other statement is correct

104 (*c*) Statement II is incorrect.
It's correct form is as follows :
Energy is always required to remove electrons from an atom and hence ionisation enthalpies are always positive.
Rest other statements are correct.

105 (*b*) On moving from lithium to fluorine across the second period, successive electrons are added to orbitals in the same principal quantum level and the shielding from the nuclear charge by the inner core of electrons does not increase very much to compensate for the increased attraction of the electron to the nucleus.
Thus, across a period, increasing nuclear charge outweighs the shielding. Consequently, the outermost electrons are held more and more tightly and the ionisation increases across a period.

106 (*d*) Statement (d) is incorrect.
It's correct form is as follows :
The process of adding electrons to the atom can either endothermic or exothermic.
Rest other statements are correct.

107 (*d*) Statement (d) is incorrect.
It's correct form is as follows :
Decrease in electronegativity down a group is accompanied by a decrease in non-metallic properties of elements.
Rest other statements are correct.

108 (*c*) Statement (c) is correct, while the other statements are incorrect. Corrected form are as follows :
(a) Electronegativity generally increases across a period from left to right and decreases down a group in the periodic table.
(b) Electronegativity value decreases with the increase in atomic radii down a group.
(d) In a period electronegativity increases with increase in non-metallic character.

109 (*d*) Statements II, III and IV are correct, while the statement I is incorrect.
It's correct form is as follows :
s-block elements are never found in pure nature because of their high reactivity.

110 (*b*) Statement II is incorrect.
It's correct form is as follows :
The chemistry of the early actinoids is more complicated than corresponding lanthanoids due to the large number of oxidation states possible for actinoid elements.
Rest other statements are correct.

111 (*a*) Statements I, II and III are correct, while the statement IV is incorrect.
It's correct form is as follows :
The non-metallic character increases as one goes from left to right across the periodic table.

112 (*a*) Statement II is incorrect.
It's correct form is as follows :
In a horizontal row, the property of elements change from metallic character on the left to non-metallic character on the right.
Rest other statements are correct.

113 (*c*) Statement IV is incorrect.
It's correct form is as follows :
The electronegativity of any given element is not constant.
Rest other statements are correct.

114 (*a*) Statement IV is incorrect.
It's correct form is as follows :
The valence of representative elements is usually equal to the number of electrons in the outermost orbitals and/or equal to eight minus the number of outermost electrons.
Rest other statements are correct.

115 (*b*) The maximum chemical reactivity at the extreme left (among alkali metals) is exhibited by the loss of an electron leading to the formation of a cation and at the extreme right (among halogens) shown by the gain of an electron forming an anion.

Thus, statement (b) is correct.

116 (*b*) 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.

117 (*c*) 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.

118 (*b*) 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.

119 (*d*) The third period have outer subshell containing maximum eight electrons and filling of electrons in 3rd period starts from $3s^1$ to $3p^6$ as

$$\overset{(1)}{3s^1}, \overset{(2)}{3s^2}, \overset{(3)}{3s^2\,3p^1}, \overset{(4)}{3s^2\,3p^2}, \overset{(5)}{3s^2\,3p^3}, \overset{(6)}{3s^2\,3p^4}, \overset{(7)}{3s^2\,3p^5}, \overset{(8)}{3s^2\,3p^6}$$

So, number of elements = eight in third period.
Thus, R is correct but A is incorrect.

120 (*d*) Sixth period contains 32 elements and seventh period is incomplete and like sixth, the period would have 32 elements.

Thus, R is correct but A is incorrect.

121 (*d*) $2p^6, 3s^2 \longrightarrow$ 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.

122 (*d*) 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.

123 (*a*) Element with electronic configuration $= [\text{Ar}]\,4s^2 3d^5$ (manganese) is a *d*-block element because last electron enters the *d*-orbital.
Thus, both A and R are correct and R is the correct explanation of A.

124 (*c*) 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, A is correct but R is incorrect.

125 (*a*) Boron has a smaller first ionisation enthalpy than beryllium because the 2*p*-electron of boron is more shielded from the nucleus by the inner core of electrons than the 2*s*-electrons of beryllium.

Thus, both A and R are correct and R is the correct explanation of A.

126 (*b*) Helium has the highest first ionisation enthalpy in the periodic table because more force of attraction acts between nuclei and electrons of 1*s*-orbital.
Ionisation enthalpy decreases from top to bottom in a group due to decrease in effective nuclear charge.

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

127 (*b*) Na^+ and Al^{3+} are isoelectronic species because they have 10 electrons each

$$Na^+ = 1s^2,\ 2s^2,\ 2p^6 = 10e^-$$

$$Al^{3+} = 1s^2,\ 2s^2,\ 2p^6 = 10e^-$$

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

128 (*a*) Na^+ and Al^{3+} have 10 electrons, so, these are called isoelectronic species and the effective nuclear charge but ionic radii of Al^{3+} is smaller than Na^+. This is because, effective nuclear charge value of Al^{3+} is greater than effective nuclear charge value of Na^+ due to larger positive charge in Al^{3+}.

Thus, both A and R are correct and R is the correct explanation of A.

129 (*b*) Be and Al show diagonal relationship because Be resembles their properties with Al. Ionic radii of Al^{3+} is smaller than Na^+. This is because, smaller size is the reason for the anomalous behaviour of Be due to which it shows diagonal relation with Al.

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

130 (*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 downward and the added electron would be farther away from the nucleus.
Thus, both A and R are correct and R is the correct explanation of A.

131 (*a*) In a group, metallic character increases and tendency to accept electrons decreases on moving down. As a result oxidising properties decreases.

Thus, both A and R are correct and R is the correct explanation of A.

134 (*b*) The correct match is

A → 2; B → 3; C → 1, D; → 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.

136 (*d*) The correct match is

A → 3; B → 4; C → 1; D, → 2,

A. $3d$ transition series ⟶ Scandium to zinc d^1 to d^{10}. So, zinc belongs to $3d$ transition series.

B. $4d$ transition series ⟶ Yttrium to cadmium (39 to 48 atomic number).
So, yttrium belongs to $4d$-transition series.

C. $4f$-inner transition series ⟶ Cerium to lutetium (58 to 71 atomic number).
So, cerium belong to $4f$-inner transition series.

D. $5f$-inner transition series ⟶ Actinium (thorium to lawrencium) 90 to 103 atomic number.
So, actinium belongs to $5f$ inner transition series.

137 (*a*) The correct match is

A → 2; B → 1; C → 3; D → 4,

A. 52 → [Kr] $4d^{10}5s^2 5p^4$ (p-block)

B. 56 → [Xe] $6s^2$ (s-block)

C. 57 → [Xe]$5d^1 6s^2$ (d-block)

D. 60 → [Xe] $4f^4 6s^2$ (f-block)

138 (*b*) The correct match is

A → 2; B → 1; C → 3,

A. f-block elements contain lanthanoids and actinoids which are termed as inner-transition elements.

B. s-block and p-block elements are representative elements.

C. 3rd period elements are typical elements.

139 (*b*) The correct match is

A → 2; B → 4; C → 1; D → 3,

A. The correct order of ionic radii

$Li^+ < Al^{3+} < Mg^{2+} < K^+$ ⟶ The cation with the greater positive charge will have a smaller radius because of the greater attraction of the electrons to the nucleus. Anion with the greater negative charge will have the larger radius.

$$\text{Positive charge} \propto \frac{1}{\text{ionic radius}}$$

$$\text{Negative charge} \propto \text{ionic radius}$$

B. The order of effective nuclear charge (ENC) is

$$Li^+ > Al^{3+} > Mg^{2+} > K^+$$

Greater positive charge, increases ENC in case of isoelectronic species. While for same group elements, ENC decreases down the group.

C. Cl > F > Br > I,
Down the group, electron affinity decreases but electron affinity of Cl is highest in halogen family.

D. F > Cl > Br > I,
Down the group, electronegativity decreases down the group but electronegativity of fluorine (F) is higher than Cl, Br and I.

141 (*d*) The correct match is

A → 4, B → 1, C → 2, D → 3,

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

142 (*a*) Mendeleev's used atomic weight as the basis of classification of elements in the periodic table. He arranged 63 elements known at that time in the periodic table on the basis of the order of their increasing atomic weights and he placed elements with similar nature in same group.

144 (*b*) Statement (b) is incorrect regarding modern periodic table.

It's correct form is as follows :

The d-block has 10 columns, because a maximum of 10 electrons can occupy all the orbitals in a d-subshell.

Rest other statements are correct.

145 (*b*) The given element

$_{114}Z$ has electronic configuration

$_{86}$ [Rn] $7s^2, 5f^{14}, 6d^{10}, 7p^2$.

In the periodic table, the element with $Z = 114$ is located in p-block (as last electron enters in p-subshell).

Period – 7th (as $n = 7$ for valence shell)

Group – 14th (for p-block elements, group number = 10 + number of electrons in the valence shell).

146 (*a*) General configuration for 17th group elements is ns^2np^5. In the third period, the principal quantum number for valence shell is three, so the electronic configuration of valence shell for the given element is $3s^2, 3p^5$. Third period starts from atomic number, $Z = 11$ and end at $Z = 18$.

Hence, the atomic number of the given element is $10 + 7 = 17$.

147 (*a*) The configuration ns^2np^4 for $n = 3$ means element belongs to third period. Since, last electron enters in the p-orbital, it belongs to p-block. For p-block elements, the group number = 10 + valence shell electrons
= 10 + (2 + 4) = 16

Hence, the element belongs to 16th group.

148 (*a*) Same group elements have similar electronic configuration, therefore have similar physical and chemical properties.

149 (*d*) In a group, metallic character increases from top to bottom as ionisation energy decreases and in a period metallic character decreases from left to right as tendency to lose electron decreases.

Therefore, the correct order is

$$K > Mg > Al > B.$$

150 (*c*) Non-metallic character in a group decreases from top to bottom but it increases in a period when we move from left to right. This is because ionisation energy increases in a period and decreases in a group.

Therefore, for the given elements the non-metallic character decreases in the order:

$$F > N > C > B > Si$$

151 (*b*) The ionic radii of isoelectronic species decreases with increase in effective nuclear charge.

Also, the size of cation is smaller than anion.

Therefore, their ionic radii increase in the following order :

$$Al^{3+} < Mg^{2+} < Na^{+} < F^{-} < O^{2-} < N^{3-}$$

152 (*a*) The size of isoelectronic species; F^-, Ne and Na^+ is affected by nuclear charge (Z). With increase in nuclear charge (atomic number), the size of the isoelectronic species decreases.

153 (*d*) Statement (d) is incorrect.
It's correct form is as follows :

Removal of electron from orbitals bearing lower n value is difficult than from orbital having higher n value, due to decrease in effective nuclear charge with increase in the value of n.

Rest other statements are correct.

154 (*c*) Nuclear mass (protons + neutrons) does not affect the valence shell. Only protons (i.e. nuclear charge), valence principal affects the valence shell.

155 (*b*) In a group, oxidising power (i.e. tendency to gain electron) decreases from top to bottom as the size increases but when we move left to right in a period it increases because size decreases.

Therefore, among F, Cl, O and N, the oxidising power decreases in the order

$$F > O > Cl > N$$

Note *Oxygen is more electronegative than chlorine. Hence, O is stronger oxidising agent than Cl.*

156 (*c*) Statement (c) is incorrect.
It's correct form is as follows :

In case of transition elements (or any elements), the order of filling of electrons in various orbital is $3p < 4s < 3d$.

Thus, 3*d*-orbital is filled when 4*s* orbital gets completely filled.

Rest other statements are correct.

157 (*c*) 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).

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

159 (*d*) Elements with atomic number, $Z = 90$ to 103 are called actinoids. Thus, terbium ($Z = 65$) is not an actinoid. Terbium belong to lanthanoids.

160 (*c*) The expected electronic configuration for Gd ($Z = 64$) is $[Xe]4f^8\ 6s^2$ but the actual electronic configuration of Gd ($Z = 64$) is $[Xe]\,4f^7\ 5d^1\ 6s^2$.

This is because of extra stability of half filled f-orbital.

162 (*d*) Anion formed after the gain of electron to the neutral atom and cation formed after the loss of electron from outer shell. Hence, cation has smaller size but anion has bigger size than its neutral atom.

Thus, correct order of size is :

$$I^- > I > I^+.$$

163 (*b*) In case of isoelectronic species,

$$\text{Ionic radii} \propto \frac{1}{\text{Nuclear charge}}$$

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

Thus, the correct order of given isoelectronic species is

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

164 (*a*) Follow the following steps to solve out the order of first ionisation enthalpies is as follows :

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 in the periodic table.	11 12 13 14 Na Mg Al Si
Step III	Follow the general trend and also keep in mind the exception.	The ionisation potential increases along a period from left to right but ionisation potential of Mg is higher than that of Al due to completely filled 3*s* orbital in Mg.
Step IV	On the above basis find the order.	The order of ionisation potential is Na < Mg > Al < Si. Thus, option (a) is the correct.

165 (*c*) As we move from Cl to I, the electron gain enthalpy (i.e. energy released in electron gain) become less and less negative due to a corresponding increase in the atomic size. However, the electron gain enthalpy of F is less negative than that of Cl due to its small size.

Thus, the negative electron gain enthalpy follows the order,

$$F < Cl > Br > I$$

166 (*a*) Electronic configuration of elements indicate that *A* is a neon (noble gas element), *B* is oxygen (group 16), *C* is sodium metal (group 1) and *D* is fluorine (group 17).

(i) Noble gases have no tendency to gain electrons since all their orbitals are completely filled.

Thus, element *A* has the least electron gain enthalpy.

(ii) Since, element *D* has one electron less and element *B* has two electrons less than the corresponding noble gas configuration, hence element *D* has the highest electron gain enthalpy followed by element *B*.

(iii) Since, element *C* has one electron in the *s*-orbital and, hence needs one more electron to complete it, therefore, electron gain enthalpy of *C* is less than that of element *B*. Combining all the facts given above, the electron gain enthalpies of the four elements increase in following order,

$$A < C < B < D$$

167 (*c*) Although, O^{2-} has noble gas configuration and isoelectronic with neon but its formation is unfavourable due to the strong electronic repulsion between the negatively charged O^- ion and the second electron being added. Hence, the electronic repulsion outweighs the stability gained by achieving noble gas configuration.

168 (*a*) The correct match is

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 $+\Delta_{eg} H$ values, therefore electronic configuration (A) corresponds to the $\Delta_{eg} H = +48 \text{ kJ mol}^{-1}$.

B. This electronic configuration corresponds to the alkali metal i.e., potassium. Alkali metals have small negative $\Delta_{eg} H$ values, hence electronic configuration (B) corresponds to $\Delta_{eg} H = -53 \text{ kJ mol}^{-1}$.

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

D. This electronic configuration corresponds to the chalcogen i.e., oxygen. Since, chalcogens have $\Delta_{eg} H$ values less negative than those of halogens, therefore, electronic configuration (D) corresponds to $\Delta_{eg} H = -141 \text{ kJmol}^{-1}$.