3 Classification of Elements and Periodicity in Properties

I. Multiple Choice Questions (Type-I)

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

   (*i*) $F^- < O^{2-} < Mg^{2+} < Na^+$ (*ii*) $Mg^{2+} < Na^+ < F^- < O^{2-}$

   (*iii*) $O^{2-} < F^- < Na^+ < Mg^{2+}$ (*iv*) $O^{2-} < F^- < Mg^{2+} < Na^+$

Ans. (*ii*)

Explanation: All of them are isoelectronic species they have same number of electrons (10). Their radii would be different because of their different nuclear charges. 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. In this case, the net repulsion of the electrons will outweigh the nuclear charge and the ion will expand in size.

2. Which of the following is not an actinoid?

   (*i*) Curium (Z = 96) (*ii*) Californium (Z = 98)

   (*iii*) Uranium (Z = 92) (*iv*) Terbium (Z = 65)

Ans. (*iv*)

Explanation: Actinoids, Th(Z = 90) N Lr (Z = 103) are characterised by the outer electronic configuration $(n-2)f^{1-14}\,(n-1)dns^2$. The last electron added to each element is filled in *f*-orbital.

3. 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:

   (*i*) $s > p > d > f$ (*ii*) $f > d > p > s$

   (*iii*) $p < d < s > f$ (*iv*) $f > p > s > d$

Ans. (*i*)

Explanation: The effective nuclear charge experienced by a valence electron in an atom will be less than the actual charge on the nucleus because of "shielding" or "screening" of the valence electron from the nucleus by the intervening core electrons. For example, the 2*s* electron in lithium is shielded from the nucleus by the inner core of 1*s* electrons.

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

   (*i*) Na < Mg > Al < Si (*ii*) Na > Mg > Al > Si

   (*iii*) Na < Mg < Al < Si (*iv*) Na > Mg > Al < Si

Ans. (*i*)

Explanation: Across a period, increasing nuclear charge outweighs the shielding. Consequently, the outermost electrons are held more and more tightly and the ionization enthalpy increases across a period. In case of Mg the outermost electron is in *s*-orbital that is a stable gas configuration and penetration effect of *s*-subshell is more as compared to Al in which outermost electron is in *p*-subshell.

5. The electronic configuration of gadolinium (Atomic number 64) is
   (*i*) [Xe] $4f^3\,5d^5\,6s^2$ (*ii*) [Xe] $4f^7\,5d^2\,6s^1$
   (*iii*) [Xe] $4f^7\,5d^1\,6s^2$ (*iv*) [Xe] $4f^8\,5d^6\,6s^2$

Ans. (*iii*)

Explanation: Gadolinium is a lanthanoid, it is a *f*-block element and the outer electronic configuration $(n-2)f^{1-14}(n-1)d^{0-1}ns^2$.

6. The statement that is **not** correct for periodic classification of elements is:
   (*i*) The properties of elements are periodic function of their atomic numbers.
   (*ii*) Non metallic elements are less in number than metallic elements.
   (*iii*) For transition elements, the 3*d*-orbitals are filled with electrons after 3*p*-orbitals and before 4*s*-orbitals.
   (*iv*) The first ionisation enthalpies of elements generally increase with increase in atomic number as we go along a period.

Ans. (*iii*)

Explanation: According to Aufbau principle, 3*d*-orbitals are filled after 4*s* and before 4*p*-orbitals as the energy of 4*s* is lesser than 3*d*.

7. Among halogens, the correct order of amount of energy released in electron gain (electron gain enthalpy) is:
   (*i*) $F > Cl > Br > I$ (*ii*) $F < Cl < Br < I$
   (*iii*) $F < Cl > Br > I$ (*iv*) $F < Cl < Br < I$

Ans. (*iii*)

Explanation: Within a group, electron gain enthalpy becomes less negative down a group. However, adding an electron to the 2*p*-orbital leads to greater repulsion than adding an electron to the larger 3*p*-orbital. Hence, the element with most negative electron gain enthalpy is chlorine.

8. The period number in the long form of the periodic table is equal to
   (*i*) magnetic quantum number of any element of the period.
   (*ii*) atomic number of any element of the period.
   (*iii*) maximum Principal quantum number of any element of the period.
   (*iv*) maximum Azimuthal quantum number of any element of the period.

Ans. (*iii*)

Explanation: The period indicates the value of *n* for the outermost or valence shell.

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

(*i*) actinoids (*ii*) transition elements
(*iii*) lanthanoids (*iv*) halogens

Ans. (*iii*)

Explanation: The sixth period (n = 6) contains 32 elements and successive electrons enter 6*s*, 4*f*, 5*d* and 6*p* orbitals, in the order ó filling up of the 4*f* orbitals begins with cerium (Z = 58) and ends at lutetium (Z = 71) to give the 4*f*-inner transition series which is called the lanthanoid series.

10. Which of the following is the correct order of size of the given species:

(*i*) $I > I^- > I^+$ (*ii*) $I^+ > I^- > I$
(*iii*) $I > I^+ > I^-$ (*iv*) $I^- > I > I^+$

Ans. (*iv*)

Explanation: A cation is smaller than its parent atom because it has fewer electrons while its nuclear charge remains the same. The size of an anion will be larger than that of the parent atom because the addition of one or more electrons would result in increased repulsion among the electrons and a decrease in effective nuclear charge.

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

$$O\,(g) + e^- \rightarrow O^-\,(g)\,;\,\Delta H^\ominus = -\,141\ \text{kJ mol}^{-1}$$
$$O^-\,(g) + e^- \rightarrow O^{2-}\,(g);\,\Delta H^\ominus = +\,780\ \text{kJ mol}^{-1}$$

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,

(*i*) oxygen is more electronegative.
(*ii*) addition of electron in oxygen results in larger size of the ion.
(*iii*) electron repulsion outweighs the stability gained by achieving noble gas configuration.
(*iv*) O^- ion has comparatively smaller size than oxygen atom.

Ans. (*iii*)

Explanation: When an electron is added to O atom to form O^- ion, energy is released. Thus, the first electron gain enthalpy of O is negative. On the other hand, when an electron is added to O^- ion to form O^{2-} ion, energy has to be given out in order to overcome the strong electronic repulsions. Thus, the second electron gain enthalpy of O is positive.

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

In the modern periodic table, elements are arranged in order of increasing atomic numbers which is related to the electronic configuration. Depending upon the type of orbitals receiving the last electron, the elements in the periodic table have been divided into four blocks, viz, *s*, *p*, *d* and *f*. The modern periodic table consists of 7 periods and 18 groups. Each period begins with the filling of a new energy shell. In accordance with the Aufbau principle, the seven periods (1 to 7) have 2, 8, 8, 18, 18, 32 and 32 elements respectively. The seventh period is still incomplete. To avoid the periodic table being too long, the two series of *f*-block elements, called lanthanoids and actinoids are placed at the bottom of the main body of the periodic table.

(*a*) The element with atomic number 57 belongs to

(*i*) *s*-block (*ii*) *p*-block

(*iii*) *d*-block (*iv*) *f*-block

Ans. (*iii*)

Explanation: Lanthanoids characterised by the filling of 4*f*-orbitals, are the elements following lanthanum from 58Ce to 71Lu. Actinoids characterised by filling of 5*f*-orbitals, are the elements following actinium from 90Th to 103Lr. Characteristic outer electronic configuration is $(n\text{-}2) f^{1-14} (n-1) d^{0-1} ns^2$.

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

(*i*) $7s^2\, 7p^6$ (*ii*) $5f^{14}\, 6d^{10}\, 7s^2\, 7p^0$

(*iii*) $4f^{14}\, 5d^{10}\, 6s^2\, 6p^6$ (*iv*) $4f^{14}\, 5d^{10}\, 6s^2\, 6p^4$

Ans. (*iii*)

Explanation: The sixth period (n = 6) contains 32 elements and successive electrons enter 6*s*, 4*f*, 5*d* and 6*p* orbitals, in the order 6 filling up of the 4*f* orbitals begins.

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

(*i*) 107 (*ii*) 118

(*iii*) 126 (*iv*) 102

Ans. (*iii*)

Explanation: The present set up of the long form of the periodic table has seven periods and four blocks. So, the maximum number of elements according to Aufbau principle which can be accomodated are 118.

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

(*i*) $1s^2\, 2s^2\, 2p^6\, 3s^2\, 3p^6\, 3d^5\, 4s^2$ (*ii*) $1s^2\, 2s^2\, 2p^6\, 3s^2\, 3p^6\, 3d^5\, 4s^2\, 4p^6$

(*iii*) $1s^2\, 2s^2\, 2p^6\, 3s^2\, 3p^6\, 3d^6\, 4s^2$ (*iv*) $1s^2\, 2s^2\, 2p^6\, 3s^2\, 3p^6\, 3d^7\, 4s^2$

Ans. (*i*)

Explanation: The atomic number of the element which lies just above the element with atomic number 43 is 25 (M*n*). Its electronic configuration is $1s^2\, 2s^2\, 2p^6\, 3s^2\, 3p^6\, 3d^5\, 4s^2$.

(*e*) The elements with atomic numbers 35, 53 and 85 are all ________.

(*i*) noble gases (*ii*) halogens

(*iii*) heavy metals (*iv*) light metals

Ans. (*ii*)

Explanation: The elements with atomic numbers 35, 53 and 85 lie in a group before noble gases i.e., halogens (group 17). Thus, the elements with atomic numbers 35, 53 and 85 are halogens.

13. Electronic configurations 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 :

(*i*) A < C < B < D (*ii*) A < B < C < D

(*iii*) D < B < C < A (*iv*) D < A < B < C

Ans. (*i*)

Explanation: Electron Gain Enthalpy: The electron gain enthalpy ($\Delta_{eg}H$) is the molar enthalpy change when an isolated gaseous atom or ion in its ground state adds an electron to form the corresponding anion.

II. Multiple Choice Questions (Type-II)

In the following qnestions two or more options may be correct.

14. Which of the following elements can show covalency greater than 4?

(*i*) Be (*ii*) P

(*iii*) S (*iv*) B

Ans. (*ii*) and (*iii*)

Explanation: Both the above elements contain vacant *d*-orbitals that is why they can extend their covalency.

15. Those elements impart colour to the flame on heating in it, the atoms of which require low energy for the ionisation (i.e., absorb energy in the visible region of spectrum). The elements of which of the following groups will impart colour to the flame?

(*i*) 2 (*ii*) 13

(*iii*) 1 (*iv*) 17

Ans. (*i*) and (*iii*)

Explanation: Group I and II elements are reactive metals with low ionization enthalpies.

16. Which of the following sequences contain atomic numbers of only representative elements?

(*i*) 3, 33, 53, 87 (*ii*) 2, 10, 22, 36

(*iii*) 7, 17, 25, 37, 48 (*iv*) 9, 35, 51, 88

Ans. (*i*) and (*iv*)

Explanation: The *p*-Block elements comprise those belonging to Group 13 to 18 and these together with the *s*-Block elements are called the Representative Elements or Main Group Elements.

17. Which of the following elements will gain one electron more readily in comparison to other elements of their group?

(*i*) S (g) (*ii*) Na (g)

(*iii*) O (g) (*iv*) Cl (g)

Ans. (*i*) and (*iv*)

Explanation: For many elements energy is released when an electron is added to the atom and the electron gain enthalpy is negative. For example, group 17 elements (the halogens) have very high negative electron gain enthalpies because they can attain stable noble gas electronic configurations by picking up an electron.

18. Which of the following statements are correct?

(*i*) Helium has the highest first ionisation enthalpy in the periodic table.

(*ii*) Chlorine has less negative electron gain enthalpy than fluorine.

(*iii*) Mercury and bromine are liquids at room temperature.

(*iv*) In any period, atomic radius of alkali metal is the highest.

Ans. (*i*), (*iii*)

Explanation: Helium being the smallest noble gas has the highest ionisation enthalpy.

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

(*i*) Zn^{2+}, Ca^{2+}, Ga^{3+}, Al^{3+} (*ii*) K^+, Ca^{2+}, Sc^{3+}, Cl^-

(*iii*) P^{3-}, S^{2-}, Cl^-, K^+ (*iv*) Ti^{4+}, Ar, Cr^{3+}, V^{5+}

Ans. (*ii*) and (*iii*)

Explanation: When we find some atoms and ions which contain the same number of electrons, we call them isoelectronic species. For example, O^{2-}, F^-, Na^+ and Mg^{2+} have the same number of electrons (10).

20. In which of the following options order of arrangement does not agree with the variation of property indicated against it?

(*i*) $Al^{3+} < Mg^{2+} < Na^+ < F^-$ (increasing ionic size)

(*ii*) B < C < N < O (increasing first ionisation enthalpy)

(*iii*) I < Br < Cl < F (increasing electron gain enthalpy)

(*iv*) Li < Na < K < Rb (increasing metallic radius)

Ans. (*ii*) and (*iii*)

Explanation: The ionisation enthalpy of N is higher than that of O due to greater stability of half-filled electronic configuration. Hence (*ii*) is incorrect.

Again in option (*iii*), the electron gain enthalpy of F is lower than that of Cl due to small size of F. Hence (*iii*) is wrong.

21. Which of the following have no unit?

(*i*) Electronegativity (*ii*) Electron gain enthalpy

(*iii*) Ionisation enthalpy (*iv*) Metallic character

Ans. (*i*) and (*iv*)

Explanation: A qualitative measure of the ability of an atom in a chemical compound to attract shared electrons to itself is called electronegativity. Unlike ionization enthalpy and electron gain enthalpy, it is not a measureable quantity.

22. Ionic radii vary in
  (*i*) inverse proportion to the effective nuclear charge.
  (*ii*) inverse proportion to the square of effective nuclear charge.
  (*iii*) direct proportion to the screening effect.
  (*iv*) direct proportion to the square of screening effect.

Ans. (*i*) and (*iii*)

Explanation: 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. In this case, the net repulsion of the electrons will outweigh the nuclear charge and the ion will expand in size so the ionic radii vary in inverse proportion to the effective nuclear charge and direct proportion to the screening effect.

23. An element belongs to 3rd period and group-13 of the periodic table. Which of the following properties will be shown by the element?
  (*i*) Good conductor of electricity
  (*ii*) Liquid, metallic
  (*iii*) Solid, metallic
  (*iv*) Solid, non metallic

Ans. (*i*) and (*iii*)

Explanation: Group-13 third period element is Aluminium.

III. Short Answer Type

24. Explain why the electron gain enthalpy of fluorine is less negative than that of chlorine.

Ans. The added electron in fluorine goes to second quantum level. Due to small size of fluorine it experiences repulsion from other electrons much more in comparison to that in chlorine because in chlorine, the electron is added to 3rd quantum level.

25. All transition elements are *d*-block elements, but all *d*-block elements are not transition elements. Explain.

Ans. Zn, Cd and Hg which have the electronic configuration, $(n\text{-}1)\ d^{10}ns^2$ do not show most of the properties of transition elements. In a way, transition metals form a bridge between the chemically active metals of *s*-block elements and the less active elements of Groups 13 and 14 and thus take their familiar name **"Transition elements"**.

26. Identify the group and valency of the element having atomic number 119. Also predict the outermost electronic configuration and write the general formula of its oxide.

Ans. Group : 1, Valency : 1
Outermost electronic configuration = $8s^1$
Formula of Oxide = M_2O

27. Ionisation enthalpies of elements of second period are given below :
Ionisation enthalpy/k cal mol^{-1} :
520, 899, 801, 1086, 1402, 1314, 1681, 2080.

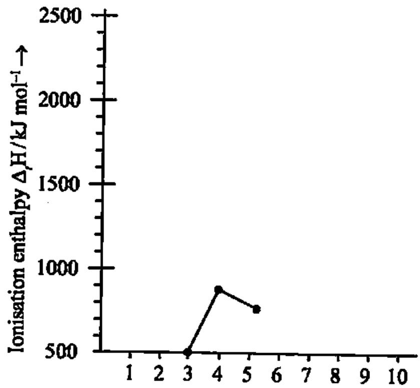
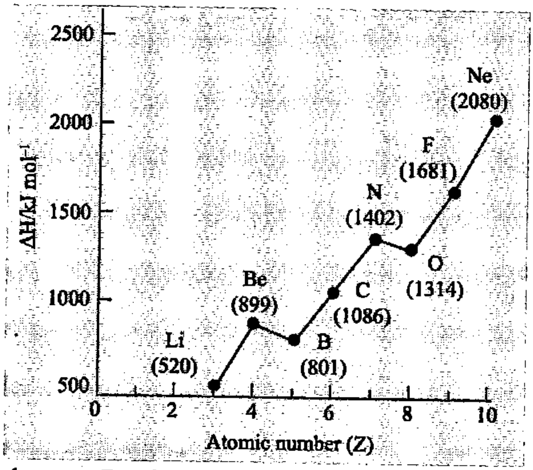


Fig. 3.1

Match the correct enthalpy with the elements and complete the graph given in Fig. 3.1. Also write symbols of elements with their atomic number.

Ans.



28. Among the elements B, Al, C and Si,

(*i*) which element has the highest first ionisation enthalpy?

(*ii*) which element has the most metallic character? Justify your answer in each case.

Ans. (*i*) Along a period, ionisation enthalpy increases and down a group ionisation enthalpy decreases. Therefore, C has the highest first ionisation enthalpy.

(*ii*) The metallic character increases down the group and decreases along a period, se, Al has the most metallic character.

29. Write four characteristic properties of *p*-block elements.

Ans. (*i*) *p*-Block elements include both metals and non-metals.

(*ii*) *p*-Block elements belong to Group 13 to 18.

(*iii*) The ionisation enthalpies are relatively higher than *s*-block elements.
(*iv*) Some of them show variable oxidation states.

30. Choose the correct order of atomic radii of fluorine and neon (in pm) out of the options given below and justify your answer.
(*i*) 72, 160 (*ii*) 160, 160
(*iii*) 72, 72 (*iv*) 160, 72

Ans. (*i*)
Explanation: The atomic size generally decreases across a period for the elements of the second period. It is because within the period, the outer electrons are in the same valence shell and the effective nuclear charge increases as the atomic number increases resulting in the increased attraction of electrons to the nucleus.

31. Illustrate by taking examples of transition elements and non-transition elements that oxidation states of elements are largely based on electronic configuration.

Ans. The oxidation state of an element in a particular compound is defined as the charge acquired by its atom or appears to have when present in the combined state with other atoms. The sign and value of oxidation state of an element depends upon its electronic configuration.
For transition elements, the variable oxidation states arise due to involvement of valence electrons as well as *d*-electrons. Their most common oxidation states are +2 and +3. For non-transition elements, the value of oxidation states is equal to the number of electrons present in the outermost shell or eight minus the number of electrons present in the outermost shell. For example, *s*-block elements have +1 or +2 oxidation states.

32. Nitrogen has positive electron gain enthalpy whereas oxygen has negative. However, oxygen has lower ionisation enthalpy than nitrogen. Explain.

Ans. This arises because in the nitrogen atom, three 2*p*-electrons reside in different atomic orbitals (Hund's rule) whereas in the oxygen atom, two of the four 2*p*-electrons must occupy the same 2*p*-orbital resulting in an increased electron-electron repulsion.
Consequently, it is easier to remove the fourth 2*p*-electron from oxygen than it is, to remove one of the three 2*p*-electrons from nitrogen.

33. First member of each group of representative elements (*i.e.*, *s* and *p*-block elements) shows anomalous behaviour. Illustrate with two examples.

Ans. **Anomalous Properties of Second Period Elements:** Their anomalous behaviour is attributed to their small size, large charge/radius ratio, high electronegativity and non-availability of *d*-orbitals in their valence shell. The first member of each group of *p*-Block elements displays greater ability to form p_π-p_π multiple bonds to itself (*e.g.*, C=C, C≡C, O=O, N≡N) and to other second period elements (*e.g.*, C=O, C≡N, N=O) compared to subsequent members of the group.

34. *p*-Block elements form acidic, basic and amphoteric oxides. Explain each property by giving two examples and also write the reactions of these oxides with water.

Ans. The oxides of *p*-block elements show acidic, basic and amphoteric properties. This is due to the following factors.

(*i*) **Ionisation enthalpy:** Higher the ionisation enthalpy, stronger will be the acid. If ionisation enthalpy of an element is high, its oxide will be acidic in nature, if low, then it will be basic and if intermediate, its oxide will be amphoteric.

(*ii*) **Electronegativity:** Higher the electronegativity of the element, more acidic is its oxide.

(*iii*) **Oxidation states:** Higher the oxidation state of the elements, stronger is the acid.

Reaction with water:

$$\underset{\text{Boron trioxide}}{B_2O_3} + 3H_2O \rightleftharpoons \underset{\text{Orthoboric acid}}{2H_3BO_3}$$

$$\underset{\text{Phosphorus pentoxide}}{P_4O_{11}} + 6H_2O \rightleftharpoons \underset{\text{Orthophosphoric acid}}{4H_3PO_4}$$

$$\underset{\text{Dichlorine heptoxide}}{Cl_2O_7} + H_2O \rightleftharpoons \underset{\text{perchloric acid}}{2HClO_4}$$

35. How would you explain the fact that first ionisation enthalpy of sodium is lower than that of magnesium but its second ionisation enthalpy is higher than that of magnesium?

Ans. The 1st ionisation enthalpy of magnesium is higher than that of Na due to higher nuclear charge and slightly smaller atomic radius of Mg than Na. After the loss of first electron, Na^+ formed has the electronic configuration of neon (2,8). The higher stability of the completely filled noble gas configuration leads to very high second ionisation enthalpy for sodium. On the other hand, Mg^+ formed after losing first electron still has one more electron in its outermost (3*s*) orbital. As a result, the second ionisation enthalpy of magnesium is much smaller than that of sodium.

36. What do you understand by exothermic reaction and endothermic reaction? Give one example of each type.

Ans. ΔH is negative for exothermic reactions which evolve heat during the reaction and ΔH is positive for endothermic reactions which absorb heat from the surroundings.

37. Arrange the elements N, P, O and S in the order of:

(*i*) increasing first ionisation enthalpy.

(*ii*) increasing non metallic character.

Give reason for the arrangement assigned.

Ans. (*i*) $S < P < N < O$

(*ii*) $P < S < N < O$

The ionisation enthalpy increases on moving from left to right in a period. Non-metallic character increases while moving from left to right across the period.

38. Explain the deviation in ionisation enthalpy of some elements from the general trend by using Fig. 3.2.

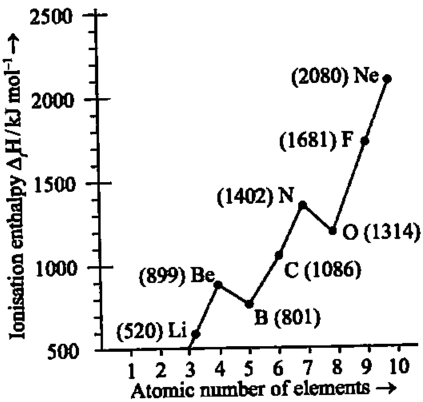


Fig. 3.2

Ans. First ionization enthalpy generally increases as we go across a period and decreases as we descend in a group. Deviation from the general trend can be explained by considering two factors:

(*i*) the attraction of electrons towards the nucleus, and

(*ii*) the repulsion of electrons from each other

39. Explain the following:

(*a*) Electronegativity of elements increase on moving from left to right in the periodic table.

(*b*) Ionisation enthalpy decrease in a group from top to bottom?

Ans. (*a*) A qualitative measure of the ability of an atom in a chemical compound to attract shared electrons to itself is called electronegativity. The increase in electronegativities across a period is accompanied by an increase in non-metallic properties (or decrease in metallic properties) of elements.

(*b*) The first ionization enthalpy generally increases as we go across a period and decreases as we descend in a group. As we go down a group, the outermost electron being increasingly farther from the nucleus, there is an increased shielding of the nuclear charge by the electrons in the inner levels. In this case, increase in shielding outweighs the increasing nuclear charge and the removal of the outermost electron requires less energy down the group.

40. How does the metallic and non-metallic character vary on moving from left to right in a period?

Ans. Metallic character: The tendency of an element to lose electrons and forms positive ions (cations) is called electropositive or metallic character. The elements having lower ionisation energies have higher tendency to lose electrons, thus they are electropositive or metallic in their behaviour.

Periodicity: In period-The electropositive or metallic character decreases from left to right in a period. In group-The electropositive or metallic character increases from top to bottom in a group.

Non-metallic character: The tendency of an element to accept electrons to form an anion is called its non-metallic or electronegative character.

Periodicity:

(*i*) **In period:** The electronegative or non-metallic character increases from left to right in a period.

(*ii*) **In group:** The electronegative or non-metallic character decreases from top to bottom in a group.

41. The radius of Na^+ cation is less than that of Na atom. Give reason.

Ans. The cations are smaller than their parent atoms due to the following reasons:

(*i*) Disappearance of the valence shell.

(*ii*) Increase of effective nuclear charge.

42. Among alkali metals which element do you expect to be least electronegative and why?

Ans. Electronegativity decreases in a group from top to bottom. Thus, caesium is the least electronegative element.

IV. Matching Type

43. Match the correct atomic radius with the element.

Element	Atomic radius (pm)
(*i*) Be	(*a*) 74
(*ii*) C	(*b*) 88
(*iii*) O	(*c*) 111
(*iv*) B	(*d*) 77
(*v*) N	(*e*) 66

Ans. (*i*) → (*c*); (*ii*) → (*d*); (*iii*) → (*e*); (*iv*) → (*b*); (*v*) → (*a*)

44. Match the correct ionisation enthalpies and electron gain enthalpies of the following elements.

Elements		ΔH_1	ΔH_2	$\Delta_{eg} H$
(*i*) Most reactive non metal	(*a*)	419	3051	– 48
(*ii*) Most reactive metal	(*b*)	1681	3374	– 328
(*iii*) Least reactive element	(*c*)	738	1451	– 40
(*iv*) Metal forming binary halide	(*d*)	2372	5251	+ 48

Ans. (*i*) → (*b*); (*ii*) → (*a*); (*iii*) → (*d*); (*iv*) → (*c*)

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

Column I	Column II
(*i*) $1s^2\ 2s^2\ 2p^6$	(*a*) –53
(*ii*) $1s^2\ 2s^2\ 2p^6\ 3s^1$	(*b*) –328
(*iii*) $1s^2\ 2s^2\ 2p^5$	(*c*) –141
(*iv*) $1s^2\ 2s^2\ 2p^4$	(*d*) +48

Ans. (*i*) → (*d*); (*ii*) → (*a*); (*iii*) → (*b*); (*iv*) → (*c*)

V. Assertion and Reason Type

In the following questions a statement of Assertion (A) followed by a statement of Reason (R) is given. Choose the correct option out of the choices given below each question.

46. Assertion (A): Generally, ionisation enthalpy increases from left to right in a period.

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

(*i*) Assertion is correct statement and reason is wrong statement.
(*ii*) Assertion and reason both are correct statements and reason is correct explanation of assertion.
(*iii*) Assertion and reason both are wrong statements.
(*iv*) Assertion is wrong statement and reason is correct statement.

Ans. (*ii*)

Explanation: Ionization enthalpy depends upon two factors:
(*i*) the attraction of electrons towards the nucleus, and
(*ii*) the repulsion of electrons from each other.

47. Assertion (A) : Boron has a smaller first ionisation enthalpy than beryllium.

Reason (R) : The penetration of a 2*s* electron to the nucleus is more than the 2*p* electron hence 2*p* electron is more shielded by the inner core of electrons than the 2*s* electrons.

(*i*) Assertion and reason both are correct statements but reason is not correct explanation for assertion.
(*ii*) Assertion is correct statement but reason is wrong statement.
(*iii*) Assertion and reason both are correct statements and reason is correct explanation for assertion.
(*iv*) Assertion and reason both are wrong statements.

Ans. (*iii*)

Explanation: In beryllium, the electron removed during the ionization is an *s*-electron whereas the electron removed during ionization of boron is a *p*-electron. The penetration of a 2*s*-electron to the nucleus is more than that of a 2*p*-electron; hence 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. Therefore, it is easier to remove the 2*p*-electron from boron compared to the removal of a 2*s*-electron from beryllium. Thus, boron has a smaller first ionization enthalpy than beryllium.

48. Assertion (A) : Electron gain enthalpy becomes less negative as we go down a group.

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

(*i*) Assertion and reason both are correct statements but reason is not correct explanation for assertion.
(*ii*) Assertion and reason both are correct statements and reason is correct explanation for assertion.
(*iii*) Assertion and reason both are wrong statements.
(*iv*) Assertion is wrong statement but reason is correct statement.

Ans. (*ii*)

Explanation: The electron gain enthalpy decreases from top to bottom in a group.

VI. Long Answer Type

49. Discuss the factors affecting electron gain enthalpy and the trend in its variation in the periodic table.

Ans. **Electron Gain Enthalpy:** The electron gain enthalpy ($\Delta_{eg}H$) is the molar enthalpy change when an isolated gaseous atom or ion in its ground state adds an electron to form the corresponding anion.

Periodicity:

(*i*) **In period:** The electron gain enthalpy increases from left to right in a period.

(*ii*) **In group:** The electron gain enthalpy decreases from top to bottom in a group.

50. Define ionisation enthalpy. Discuss the factors affecting ionisation enthalpy of the elements and its trends in the periodic table.

Ans. **Ionisation Enthalpy:** The ionisation enthalpy is the molar enthalpy change accompanying the removal of an electron from a gaseous phase atom or ion in its ground state.

Periodicity:

(*i*) Generally, the ionisation enthalpies follow the order (there are few exceptions): $(\Delta_r H_1) < (\Delta_r H_2) < (\Delta_r H_3)$

(*ii*) The ionisation enthalpy decreases on moving top to bottom in a group.

(*iii*) The ionisation enthalpy increases on moving from left to right in a period.

To understand these trends, we have to consider two factors:

(*i*) the attraction of electrons towards the nucleus, and

(*ii*) the repulsion of electrons from each other.

51. Justify the given statement with suitable examples— "the Properties of the elements are a periodic function of their atomic numbers".

Ans. The physical and chemical properties of the elements are periodic functions of their atomic numbers. Periodic Law is essentially the consequence of the periodic variation in electronic configurations, which indeed determine the physical and chemical properties of elements and their compounds. Elements having similar outer electronic configurations in their atoms are arranged in vertical columns, referred to as groups or families.

52. Write down the outermost electronic configuration of alkali metals. How will you justify their placement in group 1 of the periodic table?

Ans. ***s*-block elements:** Group-1 (Alkali metals) and Group-2 elements (Alkaline earth metals) which respectively have ns^1 and ns^2 outermost electronic configurations.

Groupwise Electronic Configurations: Elements in the same vertical column or group have similar valence shell electronic configurations, the same number of electrons in the outer orbitals, and similar properties. For example, the Group 1 elements (alkali metals), all have ns^1 valence shell electronic configuration as shown below:

Atomic number	Symbol	Electronic configuration
3	Li	$1s^2 2s^1$ (or) [He]$2s^1$
11	Na	$1s^2 2s^2 2p^6 3s^1$ (or) [Ne]$3s^1$
19	K	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$ (or) [Ar]$4s^1$
37	Rb	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 5s^1$ (or) [Kr]$5s^1$
55	Cs	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 4d^{10} 5s^2 5p^6 6s^1$ (or) [Xe]$6s^1$
87	Fr	[Rn]$7s^1$

53. Write the drawbacks in Mendeleev's periodic table that led to its modification.

Ans. Mendeleev ignored the order of atomic weights, thinking that the atomic measurements might be incorrect, and placed the elements with similar properties together. For example, iodine with lower atomic weight than that of tellurium (Group VI) was placed in Group VII along with fluorine, chlorine, bromine because of similarities in properties. At the same time, keeping his primary aim of arranging the elements of similar properties in the same group, he proposed that some of the elements were still undiscovered and, therefore, left several gaps in the table. For example, both gallium and germanium were unknown at the time Mendeleev published his Periodic Table.

54. In what manner is the long form of periodic table better than Mendeleev's periodic table? Explain with examples.

Ans. **Modern periodic law can be stated as:** The physical and chemical properties of the elements are periodic functions of their atomic numbers. Atomic number is equal to the nuclear charge (*i.e.*, number of protons) or the number of electrons in a neutral atom. It is then easy to visualize the significance of quantum numbers and electronic configurations in periodicity of elements. In fact, it is now recognized that the Periodic Law is essentially the consequence of the periodic variation in electronic configurations, which indeed determine the physical and chemical properties of elements and their compounds.

55. Discuss and compare the trend in ionisation enthalpy of the elements of group 1 with those of group 17 elements.

Ans. When we move from lithium to fluorine across the second period, successive electrons are added to orbitals in the same principal quantum level and the shielding of 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 ionization enthalpy increases across a period. As we go down a group, the outermost electron being increasingly farther from the nucleus, there is an increased shielding of the nuclear charge by the electrons in the inner levels. In this case, increase in shielding outweighs the increasing nuclear charge and the removal of the outermost electron requires less energy down a group.

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