PREVIOUS HSE QUESTIONS AND ANSWERS OF THE CHAPTER "CLASSIFICATION OF ELEMENTS AND PERIODICITY IN PROPERTIES"

1. (i) State modern periodic law. (1)
   (ii) Give any two properties of transition elements. (2)
   Ans: (i) The modern periodic law states that the properties of elements are the periodic functions of their atomic numbers.
   (ii) Transition metals are all metals. They form coloured compounds or ions. They show variable oxidation states and valencies. Most of them are paramagnetic and show catalytic properties. [Any 2 required]
2. (i) Define electron gain enthalpy. (1)
   (ii) Electron gain enthalpy of chlorine is more negative than that of fluorine. Explain. (2) [December 2021]
   Ans: (i) It is the heat change (enthalpy change) when an electron is added to the outer most shell of an isolated gaseous atom.
   (ii) This is because, when an electron is added to F, it enters into the smaller 2^{nd} shell. Due to the smaller size, the electron suffers more repulsion from the other electrons. But for Cl, the incoming electron goes to the larger 3^{rd} shell. So the electronic repulsion is low and hence Cl adds electron more easily than F.
   [OR, Due to the compactness of the 2p subshell of F, electronic repulsion is greater in F and hence it does not easily add electron.]
3. Account for the following :
   (a) Atomic radius increases from top to bottom in a group. (1)
   (b) Electron gain enthalpy of F is lower than that of Cl. (2)
   Ans: (a) This is due to increase in the no. of shells and screening effect from top to bottom in a group.
   (b) Refer the answer of Question no. 2 (ii)
4. (i) Depending upon the type of atomic orbital being filled with electrons, the elements are classified into four blocks. Name these four blocks of elements. (1)
   (ii) State the modern periodic law of elements. (2) [September 2021]
   Ans: (i) s block, p block, d block and f block
   (ii) Refer the answer of Question no. 1 (i)
5. Which one of the following has the highest ionisation enthalpy?
   (a) P (b) S (c) Cl (d) F (1)
   Ans: F
6. Atomic radius is the distance between the centre of the nucleus to the outer most shell of the atom. Explain the variation of atomic radius along groups and periods in modern periodic table. (2)
   Ans: Down a group, atomic size increases due to increase in no. of shells and shielding effect. Along a period atomic radius decreases. This is due to increase in nuclear charge from left to right in a period.
7. (a) Complete the reactions:
   (i) $Na_2O + H_2O \longrightarrow$ .....
   (ii) $Cl_2O_7 + H_2O \longrightarrow$ .....
   (b) Identify the nature of the above oxides by examining the products of the above reactions. (2) [Sept 2020]
   Ans: (a) (i) NaOH
   (ii) $HClO_4$
   (b) Na_2O is basic and Cl_2O_7 is acidic.
8. The element that has outer electronic configuration $3d^5\ 4s^1$ belongs to:
   (a) s-block (b) p-block (c) d-block (d) f-block (1)
   Ans: d-block
9. (a) Identify the group and period of an element having atomic number (Z) 25 in the periodic table. (1)
   (b) Predict the formula of the stable binary compound that would be formed by the combination of the following pairs of elements: (i) Lithium and oxygen (ii) Aluminium and iodine. (1)
   Ans: (a) The electronic configuration of the element is [Ar] $3d^5\ 4s^1$
   Period is 4 and group is 6.

(b) (i) Li_2O and (ii) AlI_3

10. Explain the general periodic trend of first ionization enthalpy along a period and group in the periodic table. (2) [March 2020]

Ans: The ionization enthalpy increases from left to right in a period due to decrease in atomic size and increase in nuclear charge. Down a group it decreases due to increase in atomic size shielding effect.

11. (a) Give the IUPAC name of the element with Atomic number 117. (1)
(b) In the modern periodic table elements in a given group have similar chemical properties. Give reason. (1)
Ans: (a) Ununseptium (Uus)
(b) Elements in a given group have same no. of valence electrons. So they have similar chemical properties.

12. Account for the following :
(a) The ionic radius of fluoride ion (F^-) is 136 pm, while the atomic radius of fluorine (F) is only 64 pm. (1)
(b) The second ionization enthalpy of an element is always greater than that of the first ionization enthalpy. (1) [July 2019]
Ans: (a) This is due to greater electronic repulsion and lesser effective nuclear charge in F^-.
(b) This is because it is more difficult to remove an electron from a positively charged ion than from a neutral atom.

13. 'Chlorine has the most negative electron gain enthalpy'. Justify the statement. (2)
Ans: Refer the answer of Question no. 2 (ii)

14. Identify the positions of Al (z=13) and S (z=16) in the periodic table with the help of their electronic configurations. Predict the formula of the compound formed between them. (2) [March 2019]
Ans: $_{13}Al$ – [Ne] $3s^2\ 3p^1$, Period – 3, Group - 13
$_{16}S$ – [Ne] $3s^2\ 3p^4$, Period – 3, Group - 16
The formula of the compound formed between Al and S is Al_2S_3.

15. Among N^{3-}, O^{2-}, F^-, Na^+ and Al^{3+}, which one has the smallest size? (1)
Ans: Al^{3+}

16. Give reasons for the following :
a) 'O' has lower ionization enthalpy than N and F.
b) Cl has higher negative electron gain enthalpy than F. (3) [August 2018]
Ans: a) The electronic configuration of O is $1s^2\ 2s^2\ 2p^4$. After the removal of one electron, O gets the stable half filled electronic configuration. So it has lower ionisation enthalpy.
b) Due to larger size and less electron-electron repulsion in chlorine.

17. Which is the acidic oxide among the following?
a) Cl_2O_7 b) Na_2O c) Al_2O_3 d) CO (1)
Ans: a) Cl_2O_7

18. Justify the following :
a) Ne has positive value for electron gain enthalpy.
b) The electron gain enthalpy of F is lower than that of Cl.
c) The size of Al^{3+} is lower than that of F. (3) [March 2018]
Ans: a) Due to stable octet configuration of Ne.
b) Due to small size and greater electronic repulsion in fluorine.
c) Due to greater effective nuclear charge in Al^{3+}.

19. a) Account for the following:
i) Transition elements are d-block elements.
ii) Chlorine has high electron gain enthalpy. (2)
b) Select isoelectronic species from the following:
O^-, F^-, Na^+, Mg^+ (2) [July 2017]
Ans: a) i) Because in transition elements, the last electron enters in the penultimate d-subshell.
ii) Refer the answer of Question no. 2 (ii)

b) F^- and Na^+

20. Electron gain enthalpy is one of the important periodic properties.
    a) Define electron gain enthalpy. (1)
    b) Explain any two factors affecting electron gain enthalpy. (2)
    c) Write the oxidation state and covalency of Al in $[AlF_6]^{3-}$ (1) [March 2017]

    Ans: a) It is the heat change (enthalpy change) when an electron is added to the outer most shell of an isolated gaseous atom.

    b) Electron gain enthalpy depends on atomic size, nuclear charge, shielding effect etc.

    c) Oxidation state = +3, Covalency = 6.

21. a) In the periodic table, elements are classified into four blocks. Explain any two blocks. (2)
    b) Account for the following:
    i) First ionisation enthalpy of Boron is less than that of carbon.
    ii) First member of a group differs from the rest of the members of the same group. (2) [September 2016]

    Ans: a) s block elements: These are elements in which the last electron enters in the outer most s-sub shell. They include elements of the groups 1 and 2. Their general outer electronic configuration is ns^1 or ns^2.

    p block elements: *These are elements in which the last electron enters in the outer most p sub shell. They include elements of the groups 13 to 18. Their general outer electronic configuration is $ns^2\ np^{1\ to\ 6}$.*

    *b) **i) $_5B – 1s^2\ 2s^2\ 2p^1$.** After the removal of one electron, B gets the stable fully filled electronic configuration. So its first ionisation enthalpy is low.*

    ***ii)** Due to their smaller size, high electronegativity, large charge to radius ratio and absence of vacant d-orbitals.*

22. a) Account for the following:
    i) Ionisation enthalpy of Nitrogen is greater than that of oxygen.
    ii) 2^{nd} period elements show anomalous behaviour. (3)
    b) A group of ions are given below. Find one pair which is not Isoelectronic.
    Na^+, Al^{3+}, Ca^{2+}, Br^-, F^- (1) [March 2016]

    Ans: a) i) Due to the stable half filled electronic configuration of Nitrogen.

    ii) *Due to their smaller size, high electronegativity, large charge to radius ratio and absence of vacant d-orbitals.*

    b) Ca^{2+} and Br^-

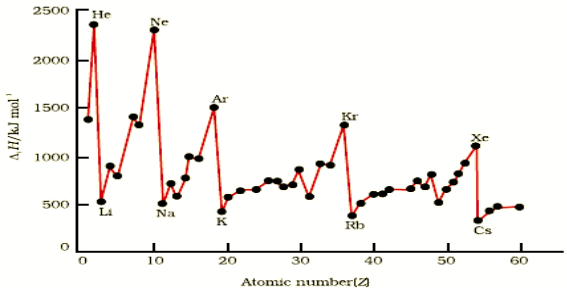
23. Names of elements with atomic numbers greater than 100 are given by IUPAC.
    a) The atomic number of element with IUPAC name 'Ununbium' is ……..
    i) 112 ii) 110 iii) 111 iv) 114 (1)
    b) Why is potassium considered as an s-block element? (1)
    c) The first ionisation enthalpy of second period elements generally increase from left to right along the period. Give reason for this general trend. (2) [March 2015]

    Ans: a) 111

    b) $_{19}K$ – [Ar] $4s^1$. Its last electron enters in the valence s-subshell. So it is considered as an s-block element.

    c) This is because of the decrease in atomic size and increase in nuclear charge from left to right along the period.

24. Ionization enthalpy and atomic radius are closely related properties.
    a) Analyze the following graph :



What conclusion can you derive from the graph regarding the first ionization enthalpies of alkali metals and noble gases? Justify your answer. (2)

b) Aluminium forms $[AlF_6]^{3-}$ whereas boron cannot form $[BF_6]^{3-}$ but forms $[BF_4]^-$ even though both belong to the same group. Explain. (2) [October 2015]

Ans: a) In a period, the alkali metals have the least ionisation enthalpy and the noble gases have the most. This is because after the removal of only one electron from the valence shell, alkali metals get the stable completely filled electronic configuration. So they have low ionisation enthalpy. Noble gases have stable octet configuration. So they have high ionisation enthalpy.

b) Due to the presence of vacant d orbitals in Al, Al can extend its covalency beyond 4. So it can form $[AlF_6]^{3-}$. But in B, there is no vacant d-orbitals. So its maximum covalency is 4.

25. a) Transition elements were placed in groups 3 and group 12 of the periodic table. Give any two characteristics of transition elements. (2)

b) Does the ionization enthalpy decrease along a group? Give reason. (2) [August 2014]

Ans: a) Transition metals are all metals. They form coloured compounds or ions. They show variable oxidation states and valencies. Most of them are paramagnetic and show catalytic properties.

b) Yes, the ionization enthalpy decreases down a group due to increase in atomic size and shielding effect.

26. a) The first member of a group of elements in the s and p block differs from the rest of the family in chemical behaviour. Write any one reason for this. (1)

b) Write the general electronic configuration of d-block elements. (1)

c) The first ionization enthalpy sodium is lower than that of magnesium but its second ionization enthalpy is higher than that of magnesium. Explain. (2) [March 2014]

Ans: a) Due to their smaller size.

b) $(n-1)d^{1 \text{ to } 10}\ ns^{0 \text{ to } 2}$

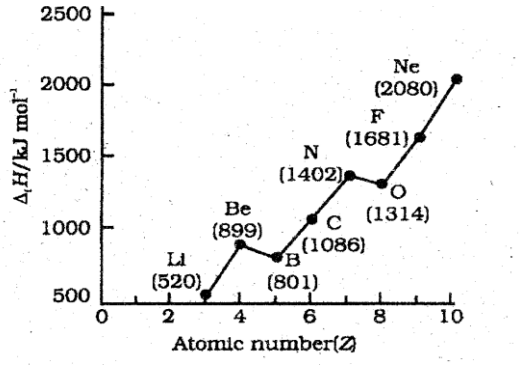
c) The electronic configuration of sodium is: $_{11}Na$ – [Ne] $3s^1$

After the removal of one electron, Na gets the stable noble gas configuration. So it has lower first ionisation enthalpy and higher second ionisation enthalpy.

27. The reactivity of an element is very much related to its ionisation enthalpy.

a) In general, ionisation enthalpy increases from left to right across a period. Give reason. (1)

b) Observe the following graph in which the first ionisation enthalpies (Δ_iH) of elements of the second period are plotted against their atomic numbers (Z):



Identify the anomalous values and justify. (3) [March 2013]

Ans: a) Due to decrease in atomic size and increase in nuclear charge across a period.

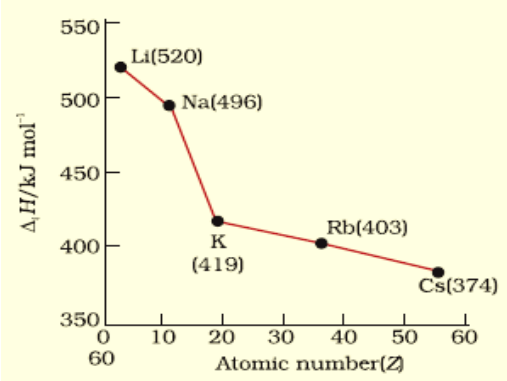
b) B and O have lower ionisation enthalpy than expected. This is because after the removal of one electron, B gets the stable fully filled configuration and O gets the stable half filled configuration.

28. a) The IUPAC has made some recommendations to name elements with atomic numbers above 100. What would be the name for the element with atomic number 104? (1)
    b) Electro negativity is the ability of an element to attract shared pair of electrons. Name a numerical scale of electro negativity of elements. (1)
    c) Give reason for the following:
    i) Phosphorus forms PCl_5 while nitrogen cannot form NCl_5. Why? (1)
    ii) The first ionization enthalpy of oxygen is smaller compared to nitrogen. (1) [September 2013]
    Ans: a) Unnilquadium (Unq)
    b) *Pauling's electronegativity scale*
    c) *i) Due to the absence of vacant d-orbitals in N*
    ii) After the removal of one electron from oxygen atom, it gets the stable half filled electronic configuration. So less energy is required to remove the electron.
29. a) Electron gain enthalpy is the amount of energy released when an isolated gaseous atom accepts an electron to form a mono-valent anion.
    The values of electron gain enthalpy with atomic number of halogens are given below:

Element	At. No.	$\Delta_{eg}H$ in kJ/mol
F	9	328
Cl	17	349
Br	35	325
I	53	295

    i) Why electron gain enthalpy decreases from chlorine to iodine? (1)
    ii) Chlorine has more electron gain enthalpy than Fluorine. Why? (1)
    b) Identify the largest and smallest ion given below:
    O^{2-}, F^-, Na^+ and Mg^{2+} (2) [September 2012]
    Ans: a) i) Due to increase in atomic size and screening effect down the group.
    ii) Due to larger size and less electron-electron repulsion in chlorine.
    b) The largest ion is O^{2-} and the smallest is Mg^{2+}.
30. Moseley modified Mendeleev's periodic law based on his observations on the X-ray spectra of elements.
    a) State the modern periodic law. (1)
    b) The IUPAC name of the element with atomic number 109 is …….. (1)

c) Analyse the following graph between ionization enthalpy and atomic number.



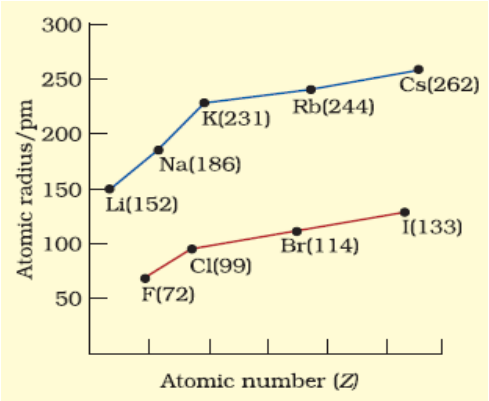
What do you observe from the graph? Give justification for your observation. (2) [March 2012]

Ans: a) The modern periodic law states that the properties of elements are the periodic functions of their atomic numbers.

b) *Unnilennium (Une)*

c) *Down a group, the ionisation enthalpy decreases. This is due to the increase in atomic size and shielding effect.*

31. a) A graph showing the variation of atomic radius with atomic number for alkali metals is given below.



Comment on the variation of atomic radius with increase in atomic number in a group. Give reason. (2)

b) What is meant by isoelectronic species? (1)

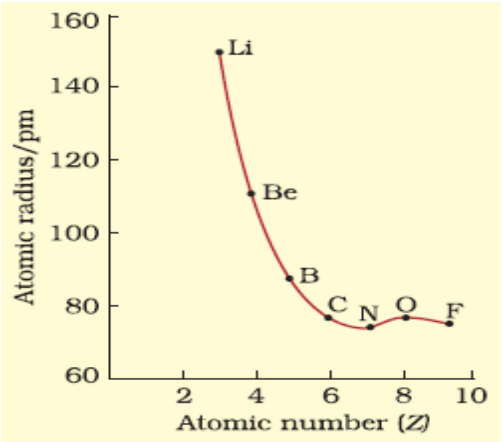
c) Select the isoelectronic species from the following. N, O^{2-}, F^-, Mg^{2+}, Al^{2+}, Na^+ (1) [October 2011]

Ans: a) Down a group, the atomic size increases due to increase in no. of shells and shielding effect.

b) *They are species having same no. of electrons.*

c) O^{2-}, F^-, $Mg^{2+}$and Na^+

32. A graph of atomic radius verses atomic number is given below:



a) What do you understand from this graph? (1)
b) Account for the observation that cations are always smaller than the parent atom while anions are always larger than the parent atom. (2)
c) Using the above graph, how will you account for the variation of ionization enthalpy in a period? (1) [March 11]

Ans: a) Along a period atomic radius decreases from left to right.

b) *This is because of the greater effective nuclear charge in cations. But in anions, the addition of one or more electrons would result in an increased electronic repulsion and a decrease in effective nuclear charge.*

c) In a period from left to right, the ionisation enthalpy increases due to decrease in atomic radius and increase in nuclear charge.

33. Development of periodic table has made the study of elements and their compounds easier.
a) Discuss about the main features of Mendeleev's periodic table. (2)
b) State the modern periodic law. (1)
c) Give the IUPAC name for the element with atomic number 112. (1) [September 2010]

Ans: a) Mendeleev classified the elements in the increasing order of their atomic weights. He proposed a periodic law which states that "the properties of elements are the periodic functions of their atomic weights"**.** *He arranged elements in horizontal rows (periods) and vertical columns (groups) in such a way that the elements with similar properties occupied in the same group. He mainly depended on the similarities in the empirical formulae and the properties of the compounds formed by the elements. He left some vacant places (gaps) for them in the periodic table and predicted some of their properties.*

b) Modern periodic law states that the properties of elements are the periodic functions of their atomic numbers.

c) Ununbium (Uub)

34. Account for the following:
a) Ionization enthalpy of nitrogen is greater than that of oxygen. (1)
b) Atomic radius decreases from left to right in a period. (1)
c) Electron gain enthalpy of F is less negative than that of Cl. (2) [March 2010]

Ans: a) Due to the stable half filled electronic configuration of Nitrogen.

b) Along a period, the no. of shells remains the same and the nuclear charge increases one by one. So the atomic radius decreases.

c) Refer the answer of Question no. 2 (ii)

35. a) Who introduced the periodic law of elements for the first time? State the law. (2)
b) State the modern periodic law of elements? (2) [March 2009]

Ans: a) Mendeleev. It states that the properties of elements are the periodic functions of their atomic weights.

b) Refer the answer of Qn. No. 1 (i)

36. Elements have electron gain enthalpy and electronegativity.
a) We two elements belong to the same group. One of us has the highest electronegativity and other, highest electron gain enthalpy. Identify us. (1)
b) Define electron gain enthalpy? (1)
c) Electron gain enthalpy values of noble gases are zero. Why? (1) [June 2008]

Ans: a) The highest electronegativity - F and the highest electron gain enthalpy – Cl.

b) It is the heat change (enthalpy change) when an electron is added to the outer most shell of an isolated gaseous atom.

c) Due to their stable octet configuration.

37. A cation is smaller than the corresponding neutral atom while anion is larger. Justify. (3) [February 2008]

Ans: Ref. the answer of the qn. No. 22 (b)