Classification of Elements and Periodicity in Properties

6.

 For Na⁺, Mg²⁺, F⁻ and O²⁻; the correct order of increasing ionic radii is

CHAPTER

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

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

- (d) $Mg^{2+} < O^{2-} < Na^+ < F^-$ (Online 2018)
- 2. Consider the following ionization enthalpies of two elements '*A*' and '*B*':

Element	Ionization enthalpy (kJ/mol)				
	1 st	2^{nd}	3 rd		
A	899	1757	14847		
В	737	1450	7731		

Which of the following statements is correct?

- (a) Both 'A' and 'B' belong to group-2 where 'A' comes below 'B'.
- (b) Both 'A' and 'B' belong to group-2 where 'B' comes below 'A'.
- (c) Both 'A' and 'B' belong to group-1 where 'B' comes below 'A'.
- (d) Both 'A' and 'B' belong to group-1 where 'A' comes below 'B'.

(Online 2017)

- **3.** The electronic configuration with the highest ionization enthalpy is
 - (a) $[Ne] 3s^2 3p^1$ (b) $[Ne] 3s^2 3p^2$ (c) $[Ne] 3s^2 3p^3$ (d) $[Ar] 3d^{10} 4s^2 4p^3$

(Online 2017)

- 4. The following statements concern elements in the periodic table. Which of the following is true?
 - (a) For group 15 elements, the stability of +5 oxidation state increases down the group.
 - (b) Elements of group 16 have lower ionization enthalpy values compared to those of group 15 in the corresponding periods.
 - (c) The group 13 elements are all metals.
 - (d) All the elements in group 17 are gases.

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(Online 2016)
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- 5. The ionic radii (in Å) of N^{3-} , O^{2-} and F^{-} are respectively (a) 1.71, 1.40 and 1.36 (b) 1.71, 1.36 and 1.40
 - (c) 1.36, 1.40 and 1.71 (d) 1.36, 1.71 and 1.40

(2015)

- Which one has the highest boiling point? (a) Kr (b) Xe (c) He (d) Ne (2015)
- 7. In the long form of the periodic table, the valence shell electronic configuration of $5s^25p^4$ corresponds to the element present in
 - (a) group 16 and period 6 (b) group 17 and period 5
 - (c) group 16 and period 5 (d) group 17 and period 6.

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(Online 2015)
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 The first ionisation potential of Na is 5.1 eV. The value of electron gain enthalpy of Na⁺ will be

(a)
$$+2.55 \text{ eV}$$
(b) -2.55 eV (c) -5.1 eV (d) -10.2 eV (2013)

- **9.** Which of the following represents the correct order of increasing first ionization enthalpy for Ca, Ba, S, Se and Ar?
 - (a) Ca < Ba < S < Se < Ar
 - (b) Ca < S < Ba < Se < Ar
 - (c) S < Se < Ca < Ba < Ar
 - (d) Ba < Ca < Se < S < Ar (2013)
- **10.** The increasing order of the ionic radii of the given isoelectronic species is
 - (a) S^{2-} , Cl^- , Ca^{2+} , K^+ (b) Ca^{2+} , K^+ , Cl^- , S^{2-} (c) K^+ , S^{2-} , Ca^{2+} , Cl^- (d) Cl^- , Ca^{2+} , K^+ , S^{2-}

(2012)

- 11. Which one of the following orders presents the correct sequence of the increasing basic nature of the given oxides?
 (a) Al₂O₃ < MgO < Na₂O < K₂O
 - (b) $MgO < K_2O < Al_2O_3 < Na_2O$
 - (c) $Na_2O < K_2O < MgO < Al_2O_3$

(d)
$$K_2O < Na_2O < Al_2O_2 < MgO$$
 (2011)

- 12. The correct sequence which shows decreasing order of the ionic radii of the element is
 - (a) $O^{2-} > F^- > Na^+ > Mg^{2+} > Al^{3+}$
 - (b) $Al^{3+} > Mg^{2+} > Na^+ > F^- > O^{2-}$
 - (c) $Na^+ > Mg^{2+} > Al^{3+} > O^{2-} > F^-$
 - (d) $Na^+ > F^- > Mg^{2+} > O^{2-} > Al^{3+}$ (2010)
- **13.** Following statements regarding the periodic trends of chemical reactivity of the alkali metals and the halogens are given. Which of these statements gives the correct picture?

- (a) The reactivity decreases in the alkali metals but increases in the halogens with increase in atomic number down the group.
- (b) In both the alkali metals and the halogens the chemical reactivity decreases with increase in atomic number down the group.
- (c) Chemical reactivity increases with increase in atomic number down the group in both the alkali metals and halogens.
- (d) In alkali metals the reactivity increases but in the halogens it decreases with increase in atomic number down the group.

(2006)

- 14. The decreasing values of bond angles from NH_3 (106°) to SbH_3 (101°) down group-15 of the periodic table is due to
 - (a) increasing bond-bond pair repulsion
 - (b) increasing *p*-orbital character in sp^3
 - (c) decreasing lone pair-bond pair repulsion
 - (d) decreasing electronegativity. (2006)
- **15.** The increasing order of the first ionisation enthalpies of the elements B, P, S and F (lowest first) is

(a)
$$F < S < P < B$$

(b) $P < S < B < F$
(c) $B < P < S < F$
(d) $B < S < P < F$
(2006)

- **16.** Which one of the following sets of ions represents a collection of isoelectronic species?
- 17. In which of the following arrangements the order is NOT according to the property indicated against it?
 - (a) $Al^{3+} \le Mg^{2+} \le Na^+ \le F^-$ increasing ionic size
 - (b) $B < C < N < O\,$ increasing first ionisation enthalpy
 - (c) I < Br < F < Cl increasing electron gain enthalpy
 - (with negative sign) (d) Li < Na < K < Rb - increasing metallic radius (2005)
- 18. Based on lattice energy and other considerations which one of the following alkali metal chlorides is expected to have the highest melting point?(a) LiCl (b) NaCl (c) KCl (d) RbCl

- 19. Lattice energy of an ionic compound depends upon(a) charge on the ion only
 - (b) size of the ion only

- (c) packing of the ion only
- (d) charge and size of the ion. (2005)
- **20.** Which among the following factors is the most important in making fluorine the strongest oxidising agent?
 - (a) Electron affinity (b) Ionization energy
 - (c) Hydration enthalpy (d) Bond dissociation energy (2004)
- **21.** The formation of the oxide ion $O^{2-}_{(g)}$ requires first an exothermic and then an endothermic step as shown below. $O_{(g)} + e^{-} = O^{-}_{(g)}$; $\Delta H^{\circ} = -142 \text{ kJmol}^{-1}$ $O^{-}_{(g)} + e^{-} = O^{2-}_{(g)}$; $\Delta H^{\circ} = 844 \text{ kJmol}^{-1}$ This is because
 - (a) oxygen is more electronegative
 - (b) oxygen has high electron affinity
 - (c) O^- ion will tend to resist the addition of another electron
 - (d) O^- ion has comparatively larger size than oxygen atom. (2004)
- **22.** Which one of the following sets of ions represents the collection of isoelectronic species?

(a)
$$K^+$$
, Ca^{2+} , Sc^{3+} , Cl^- (b) Na^+ , Ca^{2+} , Sc^{3+} , F^-

- (c) K^+ , Cl^- , Mg^{2+} , Sc^{3+} (d) Na^+ , Mg^{2+} , Al^{3+} , Cl^- . (Atomic nos.: F = 9, Cl = 17, Na = 11, Mg = 12, Al = 13, K = 19, Ca = 20, Sc = 21) (2004)
- **23.** Which one of the following ions has the highest value of ionic radius?

(a)
$$Li^+$$
 (b) B^{3+} (c) O^{2-} (d) F^- (2004)

- 24. Which one of the following groupings represents a collection of isoelectronic species?
 - (At. nos.: Cs-55, Br-35) (a) Na⁺, Ca²⁺, Mg²⁺ (b) N³⁻, F⁻, Na⁺ (c) D A^{12+} Cl₂ (d) C A^{2+} C $A^$
 - (c) Be, Al^{3+} , Cl^- (d) Ca^{2+} , Cs^+ , Br (2003)
- **25.** According to the periodic law of elements, the variation in properties of elements is related to their
 - (a) atomic masses (b) nuclear masses
 - (c) atomic numbers
 - (d) nuclear neutron-proton number ratios. (2003)
- **26.** Which is the correct order of atomic sizes?
 - (a) Ce > Sn > Yb > Lu
 - (b) Sn > Ce > Lu > Yb
 - (c) Lu > Yb > Sn > Ce
 - (d) Sn > Yb > Ce > Lu.
 - (At. Nos. : Ce = 58, Sn = 50, Yb = 70 and Lu = 71)

(2002)

ANSWER KEY											
1. (a)	2. (b)	3. (c)	4. (b)	5. (a)	6. (b)	7. (c)	8. (c)	9. (d)	10. (b)	11. (a)	12. (a)
13. (d)	14. (c)	15. (d)	16. (a)	17. (b)	18. (b)	19. (d)	20. (d)	21. (c)	22. (a)	23. (c)	24. (b)
25. (c)	26. (a)										

Explanations

1. (a) : Na⁺, Mg²⁺, F⁻ and O²⁻ are isoelectronic species. For isoelectronic species, the ionic radius increases with increase in negative charge and decreases with increase in positive charge. Thus, increasing order of ionic radii is : $Mg^{2+} < Na^+ < F^- < O^{2-}$

2. (b) : As the third ionization energy of A and B are very high as compared to corresponding second ionization energy, thus, there must be two electrons in their valence shells. Hence, elements A and B belong to group-2. On going down the group, the atomic size increases, so force of attraction between valence electron and nucleus decreases. Hence, ionization energy decreases.

Thus, 'B' comes below 'A'.3. (c) : As we move down the group, *I.E.* decreases and left to

right it increases. 4. (b) : Group 15 elements have stable half-filled (ns^2np^3)

4. (b): Group 15 elements have stable half-filled $(ns^{-}np^{-})$ configurations hence, their ionization enthalpy is higher than that of group 16 elements.

5. (a) : The ionic radii of isoelectronic ions increase with the decrease in magnitude of the nuclear charge.

$$F^-$$
 < O^{2-} < N^{3-}
1.36 Å 1.40 Å 1.71 Å

6. (b) : Boiling point increases down the group from He to Rn due to increase in van der Waals' forces of attraction as the size of the atom increases.

7. (c): $5s^25p^4$ valence shell electronic configuration corresponds to the element present in group 16 (10 + 6) and period 5 (n = 5).

8. (c) : Electron gain enthalpy = - Ionisation potential = -5.1 eV

9. (d) : Ionization enthalpy decreases from top to bottom in a group while it increases from left to right in a period.

10. (b): For isoelectronic species as effective nuclear charge increases, ionic radii decreases. Nuclear charge is maximum of the specie with maximum protons. Order of nuclear charge:

	Ca ²⁺	$> K^+ >$	Cl- >	S^{2-}
Protons :	20	19	17	16
Electrons :	18	18	18	18

Thus increasing order of ionic radii : $Ca^{2+} < K^+ < Cl^- < S^{2-}$

11. (a): While moving from left to right in periodic table basic character of oxide of elements will decrease.

$$\therefore \qquad \frac{Al_2O_3 < MgO < Na_2O}{\text{Increasing basic strength}} \Rightarrow$$

And while descending in the group basic character of corresponding oxides increases. Na $\Omega < K \Omega$

$$\therefore \qquad \frac{1 \sqrt{a_2} \sqrt{1 \sqrt{2}}}{\text{Increasing basic strength}}$$

 \therefore Correct order is Al₂O₃ < MgO < Na₂O < K₂O

12. (a): All the given species are isoelectronic. Among isoelectronic species, anions generally have greater size than cations.

Also greater, the nuclear charge (Z) of the ion, smaller the size. Thus the order is : $O^{2-}>F^->Na^+>Mg^{2+}>Al^{3+}$

13. (d) : All the alkali metals are highly reactive elements since they have a strong tendency to lose the single valence *s*-electron to form unipositive ions having inert gas configuration. This reactivity arises due to their low ionisation enthalpies and high negative values of their standard electrode potentials.

However, the reactivity of halogens decreases with increase in atomic number due to following reasons:

(i) As the size increases, the attraction for an additional electron by the nucleus becomes less.

(ii) Due to decrease in electronegativity from F to I, the bond between halogen and other elements becomes weaker and weaker.

The bond angle in ammonia is less than 109° 28' due to repulsion between lone pairs present on nitrogen atom and bonded pairs of electrons. As we move down the group, the bond angles gradually decrease due to decrease in bond pair lone pair repulsion.

In general as we move from left to right in a period, the ionisation enthalpy increases with increasing atomic number. The ionisation enthalpy decreases as we move down a group. $P(1s^2 2s^2 2p^6 3s^2 3p^3)$ has a stable half filled electronic configuration than S ($1s^2 2s^2 2p^6 3s^2 3p^4$). For this reason, ionisation enthalpy of P is higher than S.

16. (a):
$$K^+ = 19 - 1 = 18 e^-$$

 $Cl^- = 17 + 1 = 18 e^-$
 $Ca^{2+} = 20 - 2 = 18 e^-$
 $Sc^{3+} = 21 - 3 = 18 e^-$

Thus all the species are isoelectronic.

17. (b) : As we move from left to right across a period, ionisation enthalpy increases with increasing atomic number. So the order of increasing ionisation enthalpy should be B < C < N < O. But $N(1s^22s^22p^3)$ has a stable half filled electronic configuration. So, ionization enthalpy of nitrogen is greater than oxygen. So, the correct order of increasing the first ionization enthalpy is B < C < O < N. **18.** (b): In case of halides of alkali metals, melting point decreases going down the group because lattice enthalpies decreases as size of alkali metal increases. But LiCl has lower melting point in comparison to NaCl due to covalent nature. Thus, NaCl is expected to have the highest melting point among given halides.

19. (d) : The value of lattice energy depends on the charges present on the two ions and the distance between them.

20. (d) : The bond dissociation energy of F - F bond is very low. The weak F - F bond makes fluorine the strongest oxidising halogen.

21. (c) : The addition of second electron in an atom or ion is always endothermic.

22. (a) : Isoelectronic species are those which have same number of electrons.

$$\begin{split} K^+ &= 19 - 1 = 18 \ ; \ Ca^{2+} = 20 - 2 = 18 \\ Sc^{3+} &= 21 - 3 = 18 \ ; \ Cl^- = 17 + 1 = 18 \\ \text{Thus all these ions have } 18 \ \text{electrons in them.} \end{split}$$

23. (c) : This can be explained on the basis of z/e $\left\{\frac{\text{nuclear charge}}{\text{no. of electrons}}\right\}$, whereas z/e ratio increases, the size decreases

 $\left\{\frac{1}{\text{no. of electrons}}\right\}$, whereas z/e ratio increases, the size decreases and when z/e ratio decreases the size increases.

For Li⁺, $\frac{z}{e} = \frac{3}{2} = 1.5$

For B³⁺,
$$\frac{z}{e} = \frac{5}{2} = 2.5$$

For O²⁻, $\frac{z}{e} = \frac{8}{10} = 0.8$
For F⁻, $\frac{z}{e} = \frac{9}{10} = 0.9$
Hence, O²⁻ has highest value of

Hence, O²⁻ has highest value of ionic radius.

24. (b) : Isoelectronic species are the neutral atoms, cations or anions of different elements which have the same number of electrons but different nuclear charge. Number of electrons in $N^{3-} = 7 + 3 = 10$.

Number of electrons in $F^- = 9 + 1 = 10$

Number of electrons in $Na^+ = 11 - 1 = 10$

25. (c): According to modified modern periodic law, the properties of elements are periodic functions of their atomic numbers.

26. (a) : Generally as we move from left to right in a period, there is regular decrease in atomic radii and in a group as the atomic number increases the atomic radii also increases. Thus the atomic radius of Sn should be less than lanthanides. La > Sn. But due to lanthanide contraction, in case of lanthanides there is a continuous decrease in size with increase in atomic number. Hence the atomic radius follow the given trend : Ce > Sn > Yb > Lu.

