Classification of Elements and Periodicity in Properties & Chemical Bonding and Molecular Structure

1. Consider the elements Mg, Al, S, P and Si, the correct increasing order of their first ionization enthalpy is :

   A. $Mg < Al < Si < P < S$

   B. $Mg < Al < Si < S < P$

   C. $Al < Mg < S < Si < P$

   D. $Al < Mg < Si < S < P$

   Across the period, generally ionization enthalpy increases.
   IP is expected to increase in the same elemental order of third row as $Mg, Al, Si, P\ and\ S$.
   But half-filled and fully-filled configuration are stable and may change the regular trend.
   P having half-filled p-orbital has more IE_1 than S.
   Similarly, Mg has compltely filled s-orbital and more IE_1 than Al, where the 3p electron is effectively shielded by $3s$ electrons.
   Finally order should be $Al < Mg < Si < S < P$
   Hence, (d) is the correct option.

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2. Match List-I with List-II.

	List-I		List-II
	Electonic configuration of elements		$\Delta_1 H\ (in\ kJ\ mol^{-1})$
(a)	$1s^2 2s^2$	(i)	801
(b)	$1s^2 2s^2 2p^4$	(ii)	899
(c)	$1s^2 2s^2 2p^3$	(iii)	1314
(d)	$1s^2 2s^2 2p^1$	(iv)	1402

Choose the most appropriate answer from the options given below:

A. $(a) \rightarrow (i), (b) \rightarrow (iii), (c) \rightarrow (iv), (d) \rightarrow (ii)$

B. $(a) \rightarrow (i), (b) \rightarrow (iv), (c) \rightarrow (iii), (d) \rightarrow (ii)$

C. $(a) \rightarrow (iv), (b) \rightarrow (i), (c) \rightarrow (ii), (d) \rightarrow (iii)$

D. $(a) \rightarrow (ii), (b) \rightarrow (iii), (c) \rightarrow (iv), (d) \rightarrow (i)$

On moving left to right in periodic table, ionisation energy increases (generally) but group-13 elements have lesser $I.E.$ than group-2 elements due to stable ns^2 electronic configuration of group-2 elements and group-15 elements have greater $I.E.$ than group-16 elements due to half-filled stable np^3 electronic configuration of group-15 elements.
$\therefore$ Overall order of $I.E$ should be
$c > b > a > d$
Hence, D is the correct option.

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3. The correct order of electron gain enthalpy is :

- ✗ **A.** $O > S > Se > Te$
- ✗ **B.** $Te > Se > S > O$
- ✗ **C.** $S > O > Se > Te$
- ✓ **D.** $S > Se > Te > O$

The electron gain enthalpy becomes less negative as we move down a group.
As we move down a group, both the atomic size and the nuclear charge increases. But the effect of the increase in atomic size is much more pronounced than the nuclear charge.
With the increase in atomic size, the attraction of the nucleus for the incoming electron decreases. Hence, the electron gain enthalpy becomes less negative.

Because of the small size leading to repulsion of the incoming electron second period elements (here Oxygen) have low electron gain enthalpy than other element of the column. S has the highest enthalpy.
Correct order of electron gain enthalpy is,
$S > Se > Te > O$
Hence, (d) is the correct option.

4. The characteristics of elements X, Y and Z with atomic numbers, respectively, $33, 53$ and 83 are

- ✗ **A.** X and Y are metalloids and Z is a metal
- ✓ **B.** X is a metalloid, Y is a non-metal and Z is a metal
- ✗ **C.** X and Z are non-metals and Y is a metalloid.
- ✗ **D.** X, Y and Z are metals.

$X(Z = 33) = \text{Arsenic is a metalloid}$
$Y(Z = 53) = \text{Iodine is a non-metal}$
$Z(Z = 83) = \text{Bismuth is a metal}$
Option B is the correct answer.

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5. The absolute value of the electron gain enthalpy of halogens satisfies:

A. $Cl > Br > F > I$

B. $I > Br > Cl > F$

C. $F > Cl > Br > I$

D. $Cl > F > Br > I$

The magnitude of electron gain enthalpy of halogen atoms down the group shows abnormal behaviour. The $|\Delta H_{eg}|$ of F is lower than that of Cl due to its smaller size. The incoming electron experiences higher repulsive force due to valence electrons of F than Cl. The correct order is $Cl > F > Br > I$
Option d is the correct answer.

6. The ionic radius of Na^+ ion is $1.02\mathring{A}$. The ionic radii $in\ \mathring{A}$ of Mg^{2+} and Al^{3+}. respectively, are

A. 0.71 and 0.54

B. 1.05 and 0.99

C. 0.68 and 0.72

D. 0.85 and 0.99

Ionic radius of isoeletronic ions of the same period decreases due to increased nucleus charge.
Order of ionic size $Na^+ > Mg^{2+} > Al^{3+}$
Hence, option (a) is the correct.

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7. The first ionization energy of magnesium is smaller as compared to that of elements X and Y, but higher than that of Z. The elements X, Y and Z , respectively, are

   ✗ **A.** chlorine, lithium and sodium

   ✗ **B.** argon, lithium and sodium

   ✓ **C.** argon, chlorine and sodium

   ✗ **D.** neon, sodium and chlorine

   Considering the third period elements, first ionisation energy of Mg is smaller than Argon and chlorine but will be higher than Na.

   So $X \rightarrow \text{Argon}$
   $Y \rightarrow \text{Chlorine}$
   $Z \rightarrow \text{Sodium}$
   Option C is the correct answer

8. Which of the follwing atoms has the highest first ionization energy?

   ✗ **A.** Na

   ✗ **B.** K

   ✓ **C.** Sc

   ✗ **D.** Rb

   Going down the group, ionization energy decreases.
   Na, K and Rb are first group elements and the first I.E. of Na is highest among them.
   Sc is a d-block element with [Ar]$3d^1 4s^2$ configuration.
   First I.E. involves removal of electrons from a filled s-orbital which is higher than that of Na.
   C is the correct option.

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9. The ionic radii of K^+, Na^+, Al^{3+} and Mg^{2+} are in the order

A. $Na^+ < K^+ < Mg^{2+} < Al^{3+}$

B. $Al^{3+} < Mg^{2+} < K^+ < Na^+$

C. $Al^{3+} < Mg^{2+} < Na^+ < K^+$

D. $K^+ < Al^{3+} < Mg^{2+} < Na^+$

	Ionic radii (in pm)
Na^+	102
K^+	138
Mg^{2+}	72
Al^{3+}	53.5

Al, Mg and Na are in third period.
Generally among the ions of same period, higher the charge on cation smaller will be its ionic radius.
Potassium belongs to the fourth period and shall have highest radius than the rest.
$Al^{3+} < Mg^{2+} < Na^+ < K^+$
Option (c) is the correct answer.

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10. The ionic radii of F^- and O^{2-} respectively are $1.33\ \mathring{A}$ and $1.4\ \mathring{A}$ while the covalent radius of N is $0.74\ \mathring{A}$.

The correct statement for the ionic radius of N^{3-} from the following is :

A. It is smaller than O^{2-} and F^- , but bigger than of N

B. It is bigger than F^- and N, but smaller than of O^{2-}

C. It is bigger than O^{2-} and F^-

D. It is smaller than F^- and N

For isoelectronic species, as the charge on anion increases, the ionic radius increases F^-, O^{2-} and N^{3-} has 10 electrons each. The decreasing order of their ionic radii is
$N^{3-} > O^{2-} > F^-$
Now, Anions have more ionic radii than corresponding neutral atom thus anion N^{3-} will have more ionic radii than covalent radii of N.
$\therefore N^{3-}$ is bigger than both O^{2-} and F^-
Correct option is C.

11. Identify the elements X and Y using the ionisation energy values given below :

	1st Ionisation Enthalpy(KJ/mol)	2nd Ionisation Enthalpy(KJ/mol)
X	495	4563
Y	731	1450

A. $X = Na\ ;\ Y = Mg$

B. $X = Mg\ ;\ Y = F$

C. $X = F\ ;\ Y = Mg$

D. $X = Mg\ ;\ Y = Na$

Due to $2p^6$, noble gas electronic configuration, the second ionisation enthalpy of Na is very high. That's why has large difference between IE_1 and IE_2 of Mg^+ is $2p^6, 3s^1$.
After the loss of one electron, Mg^{2+} will be formed with noble gas electronic configuration. That's why it has less difference between IE_1 and IE_2.
Thus option (a) is the correct answer.

Classification of Elements and Periodicity in Properties & Chemical Bonding and Molecular Structure

12. Chalcogen group elements are :

A. O, Ti and Po

B. S, Te and Pm

C. Se, Tb and Pu

D. Se, Te and Po

Chalcogens are the chemical elements in group 16 of the periodic table according to the modern IUPAC notation. This group is also known as the oxygen family. It consists of O, S, Se, Te, and the radioactive element polonium (Po).
Ti, Pm and Pu do not belong to Chalcogen group.
Hence, the correct option is (d).

Classification of Elements and Periodicity in Properties & Chemical Bonding and Molecular Structure

13. Given below are two statements : one is labelled as Assertion (A) and the other is labelled as Reason (R).

Assertion (A) : Metallic character decreases and non-metallic character increases on moving from left to right in a period.

Reason (R) : It is due to increase in ionisation enthalpy and decrease in electron gain enthalpy, when one moves from left to right in a period.

In the light of the above statements, choose the most appropriate answer from the options given below :

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

B. (A) is true but (R) is false

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

D. (A) is false but (R) is true

Metallic character decreases on moving left to right and non-metallic character increases, it is due to increase in ionisation enthalpy. But electron gain enthalpy also increases from left to right.
Reason is not correct.
Hence, the correct option is (b)

Classification of Elements and Periodicity in Properties & Chemical Bonding and Molecular Structure

14. The electron gain enthalpy (in kJ/mol) of fluorine, chlorine, bromine and iodine, respectively, are :

- ✔ **A.** $-333, -349, -325$ and -296
- ✘ **B.** $-333, -325, -349$ and -296
- ✘ **C.** $-296, -325, -333$ and -349
- ✘ **D.** $-349, -333, -325$ and -296

The electron gain enthalpy of F is less negative than that of Cl because of its small size. The additional $e^{\ominus}$ in case of F will be added to $2p$-orbital while in case of Cl it will go in the $3p$-orbital.

As a $2p$-orbital occupies smaller region of space than $3p$-orbital, it will be more compact and $e^{\ominus} - e^{\ominus}$ repulsion would be more. Hence $e^{\ominus}$ gain enthalpy of F is less than Cl.

On going down the group from Cl to I, due to decrease in size, $e^{\ominus}$ gain enthalpy decreases.

So order of $e^{\ominus}$ gain enthalpy,
$Cl > F > Br > I$
Correct option is (a).

15. The correct order of ionic radii for the ions, $P^{3-}, S^{2-}, Ca^{2+}, K^{+}, Cl^{-}$ is

- ✘ **A.** $K^{+} > Ca^{2+} > P^{3-} > S^{2-} > Cl^{-}$
- ✘ **B.** $P^{3-} > S^{2-} > Cl^{-} > Ca^{2+} > K^{+}$
- ✔ **C.** $P^{3-} > S^{2-} > Cl^{-} > K^{+} > Ca^{2+}$
- ✘ **D.** $Cl^{-} > S^{2-} > P^{3-} > Ca^{2+} > K^{+}$

For isoelectronic species, as nuclear charge increases radius decreases.

Greater the positive charge, lesser the size of ion. Greater the negative charge, larger the size of ion.

$\therefore\ P^{3-} > S^{2-} > Cl^{-} > K^{+} > Ca^{2+}$

Classification of Elements and Periodicity in Properties & Chemical Bonding and Molecular Structure

16. Which of the following are isostructural pairs?

A. SO_4^{2-} and CrO_4^{2-}

B. $SiCl_4$ and $TiCl_4$

C. NH_3 and NO_3^-

D. BCl_3 and $BrCl_3$

A. A and C only

B. B and C only

C. A and B only

D. C and D only

Isostructural species are those which have the same shape.
SO_4^{2-} and CrO_4^{2-} have tetrahedral shape.
$SiCl_4$ and $TiCl_4$ have tetrahedral shape.
NH_3 has trigonal pyramidal shape but NO_3^- has trigonal planar shape.
BCl_3 has trigonal planar shape but $BrCl_3$ has T-shape.

So, option (c) is the correct answer.

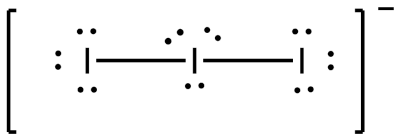
17. The correct shape and $[I—I—I]^-$ bond angles respectively in I_3^- ion are:

A. Distorted trigonal planar; 135° and 90°

B. Trigonal planar; 120°

C. T-shaped; 180° and 90°

D. Linear; 180°



Shape = Linear
Angle $\angle I-I-I$ is 180°.
Hence, option (d) is correct.

Classification of Elements and Periodicity in Properties & Chemical Bonding and Molecular Structure

18. According to molecular orbital theory, the species among the following that does not exist is:

A. He_2^-

B. Be_2

C. He_2^+

D. O_2^{2-}

Species with bond order equal to zero will not exist.

Species	Bond order
He_2^-	0.5
Be_2	0
He_2^+	0.5
O_2^{2-}	1

Hence, option (b) is correct answer.

Classification of Elements and Periodicity in Properties & Chemical Bonding and Molecular Structure

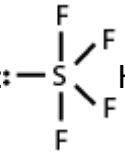
19. Which among the following species has unequal bond lengths?

A. XeF_4

B. BF_4^-

C. SF_4

D. SiF_4

SF_4 has trigonal bipyramidal geometry and see-saw shape as shown in below structure:  Here, axial bonds are longer than equatorial bonds.

Thus, SF_4 has unequal bond length.
BF_4^-, SiF_4 have tetrahedral geometry where all bonds are equal in respective compounds.
XeF_4 has square planar shape where all four $Xe - F$ bonds are equal.
Hence, option (c) is the correct answer.

Classification of Elements and Periodicity in Properties & Chemical Bonding and Molecular Structure

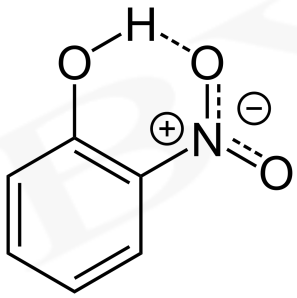
20. Given below are two statements:
Statement I: *o*-Nitrophenol is steam volatile due to intramolecular hydrogen bonding.
Statement II: *o*-Nitrophenol has high melting point due to hydrogen bonding.
In the light of the above statements, choose the most appropriate answer from the options given below:

A. Both statement I and statement II are true

B. Statement I is false but statement II is true

C. Statement I is true but statement II is false

D. Both statement I and statement II are false



It has intramolecular hydrogen bonding and steam volatile.

- Melting point is not effected by intramolecular hydrogen bonding but boiling point of a molecule decreases on intramolecular hydrogen bonding.

Hence, statement I is true, but statement II is false.

Classification of Elements and Periodicity in Properties & Chemical Bonding and Molecular Structure

21. Given below are two statements: One is labelled as Assertion A and the other is labelled as Reason R

Assertion A: Dipole-dipole interactions are only non-covalent interactions, resulting in hydrogen bond formation.

Reason R: Fluorine is the most electronegative element and hydrogen bonds in HF are symmetrical.

In the light of the above statements, choose the most appropriate answer from the options given below:

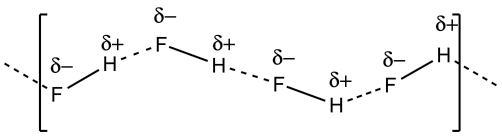
A. A is false but R is true

B. Both A and R are true and R is the correct explanation of A

C. A is true but R is false

D. Both A and R are true but R is NOT the correct explanation of A

- Dipole - Dipole are not only the interaction responsible for hydrogen bond formation. Ion-dipole can also be responsible for hydrogen bond formation.
- F is most electronegative element and anhydrous HF in solid phase has symmetrical hydrogen bonding. The strongest H-bonds are formed by F-atoms. Some hydrogen bonding also occurs in the gas, which consists of a mixture of cyclic $(HF)_6$ polymers, dimeric $(HF)_2$, and monomeric HF.



Hence, option (a) is the correct answer.

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22. Match list-I with list-II:

List-I (Molecule)	List-II (Bond order)
(a)Ne_2	(i) 1
(b)N_2	(ii) 2
(c)F_2	(iii) 0
(d)O_2	(iv) 3

Choose the correct answer from the options given below

A. $(a)-(iv);(b)-(iii);(c)-(ii);(d)-(i)$

B. $(a)-(ii);(b)-(i);(c)-(iv);(d)-(iii)$

C. $(a)-(i);(b)-(ii);(c)-(iii);(d)-(iv)$

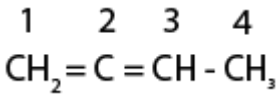
D. $(a)-(iii);(b)-(iv);(c)-(i);(d)-(ii)$

List-I (Molecule)	List-II (Bond order)
(a)Ne_2	(iii) 0
(b)N_2	(iv) 3
(c)F_2	(i) 1
(d)O_2	(ii) 2

Hence, the correct option is (d).
$(a)-(iii);(b)-(iv);(c)-(i);(d)-(ii)$

Classification of Elements and Periodicity in Properties & Chemical Bonding and Molecular Structure

23. In given molecule,



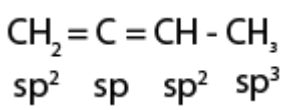
the hybridization of carbon 1, 2, 3 and 4 respectively, are :

A. sp^2, sp^2, sp^2, sp^3

B. sp^2, sp, sp^2, sp^3

C. sp^3, sp, sp^3, sp^3

D. sp^2, sp^3, sp^2, sp^3



Hybridization of carbon 1, 2, 3 and 4 respectively are sp^2, sp, sp^2 and sp^3.

Hence, the correct answer is option (b).

Classification of Elements and Periodicity in Properties & Chemical Bonding and Molecular Structure

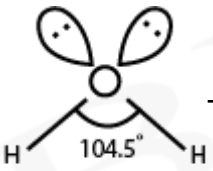
24. Given below are two statements one is labelled as Assertion A and the other is labelled as Reason R.
Assertion A: The H — O — H bond angle in water molecule is 104.5°.
Reason R: The lone pair-lone pair repulsion of electrons is higher than the bond pair-bond pair repulsion.
In the light of the above statements, choose the correct answer from the options given below.

A. A is false but R is true

B. A is true but R is false

C. Both A and R are true, and R is the correct explanation of A

D. Both A and R are true, but R is not the correct explanation of A



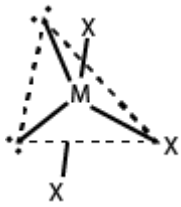
The H — O — H bond angle in water molecule is 104.5° as shown above in the structure.
Repulsion between lone pair-lone pair electrons is higher than bond pair-bond pair electrons because bond pair electrons are stuck between two nuclei. So, option (c) is correct.

Classification of Elements and Periodicity in Properties & Chemical Bonding and Molecular Structure

25. A central atom in a molecule has two lone pairs of electrons and forms three single bonds. The shape of this molecule is,

- **A.** Trigonal pyramidal
- **B.** See-saw
- **C.** T-shaped
- **D.** Trigonal planar

The shape of a molecule (MX_3) whose central atom (M) has two lone pairs of electrons and forms three single bonds is T-shaped.



26. AX is a covalent diatomic molecule where A and X are second row elements of periodic table. Based on molecular orbital theory, the bond order of AX is 2.5. The total number of
electrons in AX is
(Round off to the Nearest Integer).

Accepted Answers

15 15.0

Solution:

NO bond order :

$B.O. = \frac{1}{2}(N_b - N_a)$

NO :

$\sigma 1s^2\ \sigma^* 1s^2\ \sigma 2s^2\ \sigma^* 2s^2\ \sigma 2p_z^2\ \pi 2p_x^2\ \pi 2p_y^2\ \pi^* 2p_x^1$

$B.O. = \frac{1}{2}(10 - 5) = 2.5$

The compound AX is NO its bond order is 2.5 and it has total 15 electrons.

Note: Total number of electrons equal to 13 will also have the 2.5 bond order. But in this case neutral diatomic molecule will not be possible.

Classification of Elements and Periodicity in Properties & Chemical Bonding and Molecular Structure

27. $SF_4, BF_4^-, ClF_3, AsF_3, PCl_5, BrF_5, XeF_4, SF_6$

The number of species that have two lone pairs of electrons in their central atom is/are

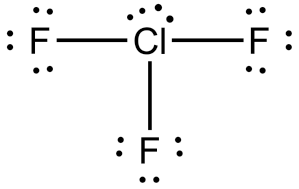
Accepted Answers

2 2.0 2.00

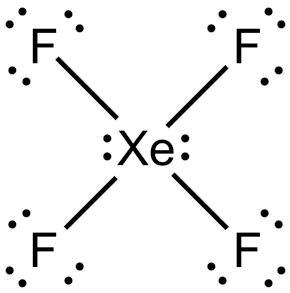
Solution:

Species	No. of lone pair of electron present on central atom
SF_4	1
BF_4^-	0
ClF_3	2
AsF_3	1
PCl_5	0
BrF_5	1
XeF_4	2
SF_6	0

ClF_3 has T-shape



XeF_4 has Square planar shape



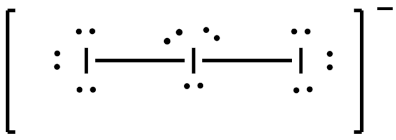
Classification of Elements and Periodicity in Properties & Chemical Bonding and Molecular Structure

28. The number of lone pairs of electrons on the central I-atom in I_3^- is

Accepted Answers

3

Solution:



Central iodine has 3 lone pair of electrons.

29. The difference between bond orders of CO and NO^+ is $\frac{x}{2}$ where x is (Round off to the Nearest Integer)

Accepted Answers

0 0.0

Solution:

Bond order of $CO = 3$

$\sigma 1s^2\ \sigma^* 1s^2\ \sigma 2s^2\ \sigma^* 2s^2\ \sigma 2p_z^2\ \pi 2p_x^2\ \pi 2p_y^2$

$B.O. = \frac{10-4}{2} = 3$

NO^+ :

$B.O. = \frac{8-2}{2} = 3$

Difference = 3 - 3 = 0

Classification of Elements and Periodicity in Properties & Chemical Bonding and Molecular Structure

30. In gaseous triethylamine the$''-C-N-C-''$ bond angle is degree.

Accepted Answers

108 108.0 108.00

Solution:

In triethylamine, nitrogen has 3 bonds pairs and 1 lone pair, so by VSEPR theory, it is sp^3 hybridised and bond angle is 108^o.

Pyramidal shape of triethylamine: