Chemical Bonding and Molecular Structure

Assertion Reason Questions

In the following question no. (7-9) a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choice.

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

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

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

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

1. Assertion (A): Sodium chloride formed by the action of chlorine gas on sodium metal is a stable compound.

Reason (R): This is because sodium and chloride ions acquire octet in sodium chloride formation.

Ans. (a) Both (A) and (R) are true and (R) is the correct explanation of (A). **Explanation:** Sodium and chloride ions in NaCl, have a complete octet. Therefore, NaCl is a stable compound.

2. Assertion (A): The form of the molecule is not explained by the octet hypothesis. **Reason (R):** The octet theory can predict a molecule's relative stability and energy.

Ans. (c) (A) is true but (R) is false.

Explanation: The octet rule does not account for the shape of molecules or explain their relative stability, and it is completely mute concerning a molecule's energy.

3. Assertion (A): For the identical halides, the order of lattice energy is LiF > NaF > KF. **Reason (R):** From Li to K, the size of alkali metals rises.

Ans. (b) Both (A) and (R) are true but (R) is not the correct explanation of (A). **Explanation:** As we know that the size of the cation or anion is inversely proportional with the lattice energy. Since the anion is identical in all cases, the lattice energy is only dependent on the size of the cation. The following is the size order of the specified cations in ascending order:

Li+ < Na+ < K+

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As a result, the order of lattice energy is: LiF > NaF > KF

4. Assertion (A): Though the central atom of both NH3 and H2O molecules are sp³ hybridised, yet H-N-H bond angle is greater than that of H-O-H.

Reason (R): This is because the nitrogen atom has one lone pair and the oxygen atom has two lone pairs.

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

Explanation: Lone pairs produce more repulsion than bond pairs. So, the angle will decrease with the increase in repulsion. In this case, nitrogen has one lone pair and oxygen has two lone pairs. Because of the presence of two lone pairs in oxygen bond angle of H₂O will be less compared to that of NH3.

5. Assertion (A): Among the two O-H bonds in H2O molecule, the energy required to break the first O-H bond and the other O-H bond is the same.

Reason (R): The electronic environment around oxygen is the same even after the breakage of one O-H bond.

Ans. (d) (A) is false but (R) is true.

Explanation: To break the different bonds in the same molecule, different energies are given. So, for breaking the first and second O-H bonds in H₂O molecule different energies are given. The electronic environment around the oxygen will change after breaking one of the O-H bonds.

6. Assertion (A): The dipole moment helps to predict whether the molecule is polar or non-polar.

Reason (R): The dipole moment helps to predict the geometry of molecules.

Ans. (a) Both (A) and (R) are true and (R) is the correct explanation of (A). **Explanation:** The linear triatomic molecule like CO2 have no dipole moment because the two bond moment (polarity) cancel each other. Therefore, geometry of molecule can be predicted by the value of dipole moment.

7. Assertion (A): Both carbon and oxygen bond lengths are equal in acetate ion. **Reason (R):** Bond length decreases with the multiplicity of bond between two atoms.



Ans. (b) Both (A) and (R) are true but (R) is not the correct explanation of (A). **Explanation:** Due to the resonance in acetate ion, the negative charge spreads over the molecule equally and hence, they have equal carbon and oxygen bond length.

$$\underset{H_{3}C}\overset{;;;}{\overset{;;}{\underset{\underline{}},\underline{0};}} \longleftrightarrow \underset{H_{3}C}\overset{;;;;}{\overset{;;}{\underset{\underline{}},\underline{0};}} \equiv \underset{H_{3}C}\overset{;;;;}{\overset{;;}{\underset{\underline{}},\underline{0};}} \equiv \underset{H_{3}C}\overset{;;;;;;}{\overset{;;;}{\underset{\underline{}},\underline{0};}}$$

Bond length decreases with the multiplicity of bond between two atoms. For example: bond length of ethane > ethene > ethyne. So, both the assertion and reason are true but the reason does not explain the assertion correctly.

8. Assertion (A): The H2O molecule has a bent shape.

Reason (R): The water molecule has lone pairs which make the geometry deviate from the tetrahedral geometry.

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

Explanation: The H2O molecule has four electron pairs, out of which two are bond pairs and two are lone pairs which make the molecule deviate from the original structure.



9. Assertion (A): According to VBT, the shape of a molecule depends on the number of valence electrons present around the central

atom.

Reason (R): The shape of SF4 is a see- saw due to the extra valence electron pair present on the central atom Sulphur.

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

Explanation: Both statements are correct. The sulphur atom has six valence electrons, out of which four electrons are satisfied by fluorine molecules and a pair remain as lone pair of electrons.





See-saw shape of SF4 structure.

10. Assertion (A): The isolated hydrogen atom is less stable than a hydrogen molecule.

Reason (R): The two hydrogen atoms are combined to get stability.

Ans. (a) Both (A) and (R) are true and (R) is the correct explanation of (A). **Explanation:** All the molecules tend to attain stability. During the formation of hydrogen molecules, the two atoms of hydrogen combine to form molecules with a release of energy which reflects that isolated atoms of hydrogen are less stable than a hydrogen molecule.

 $H_{(g)} + H_{(g)} \rightarrow H_{2(g)} + 435.8 \text{ kJmol}^{-1}$

11. Assertion (A): The sigma bond is stronger than the pi-bond. **Reason (R):** This is due to the greater extent of overlapping of pi bonds.

Ans. (c) (A) is true but (R) is false.

Explanation: The sigma bond is stronger due to the greater extent of overlapping between the atomic orbital. This reason is incorrect because the greater extent of overlapping is seen in the sigma bond, not in the pi-bond.

12. Assertion (A): NO+, and CN both have the same bond order and magnetism. **Reason (R):** NO+, and CN are isoelectronic

species.

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



Explanation: For NO+,

 $\sigma 1s^2 < \sigma^* 1s^2 < \sigma 2s^2 < \sigma^* 2s^2 < (\pi 2p_x^2 = \pi 2p_y^2)$ $< \sigma 2p_z$

Bond order = 3 and diamagnetic in nature. For CN^{-}

 $\sigma 1s^2 < \sigma^* 1s^2 < \sigma 2s^2 < \sigma^* 2s^2 < (\pi 2p_x^2 = \pi 2p_y^2)$ $< \sigma 2p_z$

Bond order = 3 and diamagnetic in nature.

Bond order 3 and diamagnetic in nature.

13. Assertion (A): NH3 molecule is sp³ hybridized.

Reason (R): The geometry of NH3

molecule is pyramidal.

Ans. (b) Both (A) and (R) are true but (R) is not the correct explanation of (A).

Explanation: Total electron pair: $\frac{(5+3)}{2} = 4$ Total bond pairs: 3 Total lone pair: (4 - 3) = 1

Clearly, sp3 hybridized molecule with 3 bond pair and 1 lone pair and shape is pyramidal. Here, due to sp³ hybridisation, shape is pyramidal, not the vice-versa.

14. Assertion (A): When Px orbital combine with Py orbital than a sigma bond is produced.

Reason (R): Atomic orbitals of similar symmetry results in positive overlap.

Ans. (d) (A) is false but (R) is true.

Explanation: Px cannot combine with Py to form a sigma bond.

15. Assertion (A): SF6 and PFs are examples of expanded octet rule. **Reason (R):** P in PFS and S in SF6 are sp³d and sp³d² hybridisation respectively.



Ans. (b) Both (A) and (R) are true but (R) is not the correct explanation of (A). **Explanation:** For SF6,

$$H = \frac{(6+6)}{2} = 6$$

Total bond pairs: 6 Total lone pair: (6 - 6) = 0Hybridisation: sp^3d^2 For PF₅,

$$H = \frac{(5+5)}{2} = 5$$

Total bond pairs: 5 Total lone pair: (5 - 5) = 0Hybridisation: sp^3d

16. Assertion (A): Boiling point of p-nitrophenol is greater than that of o-nitrophenol. **Reason (R):** There is intermolecular hydrogen bonding in p-nitrophenol and intermolecular hydrogen bonding in o-nitrophenol.

Ans. (c) (A) is true but (R) is false.

Explanation: There is intermolecular hydrogen bonding in p-nitrophenol and intramolecular hydrogen bonding in o-nitrophenol. As intramolecular hydrogen bonding in o-nitrophenol prevents further association, it has a lower boiling point than p-nitrophenol.

17. Assertion (A): NH₃ has the highest boiling point in the hydride of group 15. **Reason (R):** NH₃ shows strong intermolecular hydrogen bonding.

Ans. (d) (A) is false but (R) is true.

Explanation: Down the group, the boiling point of hydrides generally increases due to increase in van der Waals forces. But due to the presence of H-bonding in NH₃, its boiling point is higher than that of PH₃ as well as AsH₃ but van der Waals forces in bigger Sb molecules dominate the H-bonding in NH₃ and therefore, the boiling point of SbH₃ is greater than that of NH₃. The correct order of boiling point of group 15 hydrides is PH₃ < ASH₃ < NH₃ < SbH₃ < BiH₃.



18. Assertion (A): Alcohols in spite of being covalent compounds are soluble in water. **Reason (R):** Compounds whose molecules are able to form hydrogen bonding with water are soluble in them.

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

Explanation: Because their molecules can form intermolecular hydrogen bonding with water molecules.

