

Chemical Bonding and Molecular Structure — NEET Chemistry PYQ (2005-2021)

Class 11 Chemistry · 68 real NEET & AIPMT questions, year-tagged · answers checked by RankUp

NEET 2021

1. BF_3 is planar and electron deficient compound. Hybridization and number of electrons around the central atom, respectively are :

- (A) sp^3 and 4
- (B) sp^3 and 6
- (C) sp^2 and 6
- (D) sp^2 and 8

NEET 2021

2. Match List - I with List - II.

List - I | List - II

(a) PCl_5 | (i) Square pyramidal

(b) SF_6 | (ii) Trigonal planar

(c) BrF_5 | (iii) Octahedral

(d) BF_3 | (iv) Trigonal bipyramidal

Choose the correct answer from the options given below.

- (A) (a)-(iv), (b)-(iii), (c)-(i), (d)-(ii)
- (B) (a)-(ii), (b)-(iii), (c)-(iv), (d)-(i)
- (C) (a)-(iii), (b)-(i), (c)-(iv), (d)-(ii)
- (D) (a)-(iv), (b)-(iii), (c)-(ii), (d)-(i)

NEET 2021

3. Which of the following molecules is non-polar in nature ?

- (A) POCl_3
- (B) CH_2O
- (C) SbCl_5
- (D) NO_2

NEET 2020 · Q91

4. Identify a molecule which does not exist.

- (A) He_2
- (B) Li_2
- (C) C_2
- (D) O_2

NEET 2020 · Q98

5. Which of the following set of molecules will have zero dipole moment ?

- (A) Ammonia, beryllium difluoride, water, 1,4-dichlorobenzene
- (B) Boron trifluoride, hydrogen fluoride, carbon dioxide, 1,3-dichlorobenzene
- (C) Nitrogen trifluoride, beryllium difluoride, water, 1,3-dichlorobenzene
- (D) Boron trifluoride, beryllium difluoride, carbon dioxide, 1,4-dichlorobenzene

NEET 2019 · Q59

6. Which of the following diatomic molecular species has only π bonds according to Molecular Orbital Theory?

- (A) O_2
- (B) N_2
- (C) C_2
- (D) Be_2

NEET 2018 · Q51

7. In the structure of ClF_3 , the number of lone pairs of electrons on central atom 'Cl' is

- (A) four
- (B) two
- (C) one
- (D) three

NEET 2018 · Q87

8. Consider the following species: CN^+ , CN^- , NO and CN. Which one of these will have the highest bond order?

- (A) CN^+
- (B) CN^-
- (C) NO
- (D) CN

NEET 2018 · Q88

9. Magnesium reacts with an element (X) to form an ionic compound. If the ground state electronic configuration of (X) is $1s^2 2s^2 2p^3$, the simplest formula for this compound is

- (A) Mg_2X
- (B) MgX_2
- (C) Mg_2X_3
- (D) Mg_3X_2

NEET 2017 · Q4

10. Which of the following pairs of compounds is isoelectronic and isostructural?

- (A) BeCl_2 , XeF_2
- (B) TeI_2 , XeF_2
- (C) IBr_2^- , XeF_2
- (D) IF_3 , XeF_2

NEET 2017 · Q5

11. The species, having bond angles of 120° is:

- (A) PH_3
- (B) ClF_3
- (C) NCl_3
- (D) BCl_3

NEET 2017 · Q7

12. Which one of the following pairs of species have the same bond order?

- (A) CO, NO
- (B) O_2 , NO^+
- (C) CN^- , CO
- (D) N_2 , O_2^-

NEET 2017 (Gujarati paper) · Q13

13. Which of the following hydrides has the largest bond angle?

- (A) H_2S
- (B) H_2Te
- (C) H_2O
- (D) H_2Se

NEET 2017 (Gujarati paper) · Q42

14. Which of the following pair of species is not iso-structural?

- (A) ICl_4^- , XeF_4
- (B) ClO_3^- , CO_3^{2-}
- (C) IBr_2^- , XeF_2
- (D) BrO_3^- , XeO_3

NEET 2016 Phase 2 · Q65

15. The hybridizations of atomic orbitals of nitrogen in NO_2^+ , NO_3^- and NH_4^+ respectively are

- (A) sp , sp^3 and sp^2
- (B) sp^2 , sp^3 and sp
- (C) sp , sp^2 and sp^3
- (D) sp^2 , sp and sp^3

NEET 2016 Phase 2 · Q71

16. The correct geometry and hybridization for XeF_4 are

- (A) octahedral, sp^3d^2
- (B) trigonal bipyramidal, sp^3d
- (C) planar triangle, sp^3d^3
- (D) square planar, sp^3d^2

NEET 2016 Phase 1 · Q46

17. Consider the molecules CH_4 , NH_3 and H_2O . Which of the given statements is false?

- (A) The H-C-H bond angle in CH_4 , the H-N-H bond angle in NH_3 , and the H-O-H bond angle in H_2O are all greater than 90° .
- (B) The H-O-H bond angle in H_2O is larger than the H-C-H bond angle in CH_4 .
- (C) The H-O-H bond angle in H_2O is smaller than the H-N-H bond angle in NH_3 .
- (D) The H-C-H bond angle in CH_4 is larger than the H-N-H bond angle in NH_3 .

NEET 2016 Phase 1 · Q70

18. Predict the correct order among the following:

- (A) lone pair - lone pair > lone pair - bond pair > bond pair - bond pair
- (B) lone pair - lone pair > bond pair - bond pair > lone pair - bond pair
- (C) bond pair - bond pair > lone pair - bond pair > lone pair - lone pair
- (D) lone pair - bond pair > bond pair - bond pair > lone pair - lone pair

NEET 2016 Phase 1 · Q73

19. Match the compounds given in column I with the hybridisation and shape given in column II and mark the correct option.

Column I: (a) XeF_6 , (b) XeO_3 , (c) XeOF_4 , (d) XeF_4

Column II: (i) distorted octahedral, (ii) square planar, (iii) pyramidal, (iv) square pyramidal

- (A) XeF_6 - distorted octahedral; XeO_3 - pyramidal; XeOF_4 - square pyramidal; XeF_4 - square planar
- (B) XeF_6 - distorted octahedral; XeO_3 - square planar; XeOF_4 - square pyramidal; XeF_4 - pyramidal
- (C) XeF_6 - square pyramidal; XeO_3 - pyramidal; XeOF_4 - distorted octahedral; XeF_4 - square planar
- (D) XeF_6 - square pyramidal; XeO_3 - distorted octahedral; XeOF_4 - square planar; XeF_4 - pyramidal

AIPMT 2015

20. The enolic form of ethyl acetoacetate, $\text{CH}_3\text{-C(OH)=CH-COOC}_2\text{H}_5$ (in equilibrium with the keto form $\text{CH}_3\text{-CO-CH}_2\text{-COOC}_2\text{H}_5$), has:

- (A) 9 sigma bonds and 1 pi - bond
- (B) 18 sigma bonds and 2 pi - bonds
- (C) 16 sigma bonds and 1 pi-bond
- (D) 9 sigma bonds and 2 pi - bonds

AIPMT 2015

21. Which of the following species contain equal number of σ - and π -bonds?

- (A) $\text{CH}_2(\text{CN})_2$
- (B) HCO_3^-
- (C) XeO_4
- (D) $(\text{CN})_2$

AIPMT 2015

22. The correct bond order in the following species is:

- (A) $O_2^- < O_2^+ < O_2^{2+}$
- (B) $O_2^{2+} < O_2^+ < O_2^-$
- (C) $O_2^{2+} < O_2^- < O_2^+$
- (D) $O_2^+ < O_2^- < O_2^{2+}$

AIPMT 2015

23. Which of the following pairs of ions are isoelectronic and isostructural?

- (A) ClO_3^- , SO_3^{2-}
- (B) CO_3^{2-} , SO_3^{2-}
- (C) ClO_3^- , CO_3^{2-}
- (D) SO_3^{2-} , NO_3^-

AIPMT 2015

24. Which of the following options represents the correct bond order?

- (A) $O_2^- < O_2 > O_2^+$
- (B) $O_2^- > O_2 > O_2^+$
- (C) $O_2^- < O_2 < O_2^+$
- (D) $O_2^- > O_2 < O_2^+$

AIPMT 2015

25. Maximum bond angle at nitrogen is present in which of the following?

- (A) NO_3^-
- (B) NO_2
- (C) NO_2^-
- (D) NO_2^+

AIPMT 2014

26. Which of the following organic compounds has same hybridization as its combustion product (CO_2)?

- (A) Ethyne
- (B) Ethene
- (C) Ethanol
- (D) Ethane

AIPMT 2014

27. Which one of the following species has plane triangular shape?

- (A) NO_3^-
- (B) NO_2^-
- (C) CO_2
- (D) N_3^-

AIPMT 2014

28. Which of the following molecules has the maximum dipole moment?

- (A) CH_4
- (B) NH_3
- (C) NF_3
- (D) CO_2

NEET 2013

29. Which of the following is paramagnetic ?

- (A) CO
- (B) O_2^-
- (C) CN^-
- (D) NO^+

NEET 2013

30. XeF_2 is isostructural with

- (A) TeF_2
- (B) ICl_2^-
- (C) SbCl_3
- (D) BaCl_2

NEET 2013

31. Which of the following is electron-deficient?

- (A) $(\text{CH}_3)_2$
- (B) $(\text{SiH}_3)_2$
- (C) $(\text{BH}_3)_2$
- (D) PH_3

NEET 2013

32. Which one of the following molecules contains no π bond?

- (A) CO_2
- (B) H_2O
- (C) SO_2
- (D) NO_2

NEET 2013

33. Which of the following is a polar molecule ?

- (A) BF_3
- (B) SF_4
- (C) SiF_4
- (D) XeF_4

AIPMT 2012 Mains

34. During change of O_2 to O_2^- ion, the electron adds on which one of the following orbitals?

- (A) π^* orbital
- (B) π orbital
- (C) σ^* orbital
- (D) σ orbital

AIPMT 2012 Mains

35. Four diatomic species are listed below. Identify the correct order in which the bond order is increasing in them:

- (A) $\text{NO} < \text{O}_2^- < \text{C}_2^{2-} < \text{He}_2^+$
- (B) $\text{O}_2^- < \text{NO} < \text{C}_2^{2-} < \text{He}_2^+$
- (C) $\text{C}_2^{2-} < \text{He}_2^+ < \text{O}_2^- < \text{NO}$
- (D) $\text{He}_2^+ < \text{O}_2^- < \text{NO} < \text{C}_2^{2-}$

AIPMT 2012 Prelims

36. Which one of the following pairs is isostructural (i.e. having the same shape and hybridization)?

- (A) BF_4^- and NH_4^+
- (B) BCl_3 and BrCl_3
- (C) NH_3 and NO_3^-
- (D) NF_3 and BF_3

AIPMT 2012 Prelims

37. Bond order of 1.5 is shown by:

- (A) O_2
- (B) O_2^+
- (C) O_2^-
- (D) O_2^{2-}

AIPMT 2012 Prelims

38. The pair of species with the same bond order is

- (A) N_2 , O_2
- (B) O_2^{2-} , B_2
- (C) O_2^+ , NO^+
- (D) NO , CO

AIPMT 2012 Prelims

39. Which of the following species contains three bond pairs and one lone pair around the central atom?

- (A) PCl_3
- (B) H_2O
- (C) BF_3
- (D) NH_2^-

AIPMT 2011 Mains

40. The pairs of species of oxygen and their magnetic behaviours are noted below. Which of the following presents the correct description?

- (A) O_2^+ , O_2 – Both paramagnetic
- (B) O , O_2^{2-} – Both paramagnetic
- (C) O_2^- , O_2^{2-} – Both diamagnetic
- (D) O^+ , O_2^{2-} – Both paramagnetic

AIPMT 2011 Prelims

41. The correct order of increasing bond length of C-H, C-O, C-C and C=C is

- (A) $\text{C-H} < \text{C-O} < \text{C-C} < \text{C=C}$
- (B) $\text{C-H} < \text{C=C} < \text{C-O} < \text{C-C}$
- (C) $\text{C-C} < \text{C=C} < \text{C-O} < \text{C-H}$
- (D) $\text{C-O} < \text{C-H} < \text{C-C} < \text{C=C}$

AIPMT 2011 Prelims

42. Which of the following is least likely to behave as Lewis base?

- (A) OH^-
- (B) H_2O
- (C) NH_3
- (D) BF_3

AIPMT 2011 Prelims

43. Which of the following has the minimum bond length?

- (A) O_2
- (B) O_2^+
- (C) O_2^-
- (D) O_2^{2-}

AIPMT 2010 Mains · Q102

44. In which of the following molecules the central atom does not have sp^3 hybridization?

- (A) CH_4
- (B) SF_4
- (C) BF_4^-
- (D) NH_4^+

AIPMT 2010 Mains · Q116

45. Some of the properties of the two species, NO_3^- and H_3O^+ are described below. Which one of them is correct?

- (A) Dissimilar in hybridization for the central atom with different structures
- (B) Isostructural with same hybridization for the central atom
- (C) Isostructural with different hybridization for the central atom
- (D) Similar in hybridization for the central atom with different structures

46. Which one of the following species does not exist under normal conditions?

- (A) Li_2
- (B) Be_2^+
- (C) Be_2
- (D) B_2

47. In which of the following pairs of molecules/ions, the central atoms have sp^2 hybridization?

- (A) BF_3 and NH_2^-
- (B) NO_2^- and NH_3
- (C) BF_3 and NO_2^-
- (D) NH_2^- and H_2O

48. In which one of the following species the central atom has the type of hybridisation which is not the same as that present in the other three?

- (A) PCl_5
- (B) SF_4
- (C) I_3^-
- (D) SbCl_5^{2-}

49. Which of the following molecular hydrides acts as a Lewis acid?

- (A) CH_4
- (B) NH_3
- (C) H_2O
- (D) B_2H_6

50. What is the dominant intermolecular force or bond that must be overcome in converting liquid CH_3OH to a gas?

- (A) Dipole-dipole interaction
- (B) Covalent bonds
- (C) London dispersion force
- (D) Hydrogen bonding

51. According to MO theory which of the following lists ranks the nitrogen species in terms of increasing bond order?

- (A) $\text{N}_2^{2-} < \text{N}_2^- < \text{N}_2$
- (B) $\text{N}_2 < \text{N}_2^{2-} < \text{N}_2^-$
- (C) $\text{N}_2^- < \text{N}_2^{2-} < \text{N}_2$
- (D) $\text{N}_2^- < \text{N}_2 < \text{N}_2^{2-}$

52. In which of the following molecules / ions BF_3 , NO_2^- , NH_2^- and H_2O , the central atom is sp^2 hybridized?

- (A) NH_2^- and H_2O
- (B) NO_2^- and H_2O
- (C) BF_3 and NO_2^-
- (D) NO_2^- and NH_2^-

53. The angular shape of ozone molecule (O_3) consists of

- (A) 2 sigma and 1 pi bond
- (B) 1 sigma and 2 pi bonds
- (C) 2 sigma and 2 pi bonds
- (D) 1 sigma and 1 pi bond

54. The correct order of increasing bond angles in the following triatomic species is

- (A) $NO_2^+ < NO_2^- < NO_2$
- (B) $NO_2^- < NO_2^+ < NO_2$
- (C) $NO_2^- < NO_2 < NO_2^+$
- (D) $NO_2^+ < NO_2 < NO_2^-$

55. Four diatomic species are listed below in different sequences. Which of these presents the correct order of their increasing bond order?

- (A) $He_2^+ < O_2^- < NO < C_2^{2-}$
- (B) $O_2^- < NO < C_2^{2-} < He_2^+$
- (C) $NO < C_2^{2-} < O_2^- < He_2^+$
- (D) $C_2^{2-} < He_2^+ < NO < O_2^-$

56. In which of the following pairs, the two species are iso-structure?

- (A) SO_3^{2-} and NO_3^-
- (B) BF_3 and NF_3
- (C) BrO_3^- and XeO_3
- (D) SF_4 and XeF_4

57. The correct order of C-O bond length among CO , CO_3^{2-} , CO_2 is

- (A) $CO < CO_3^{2-} < CO_2$
- (B) $CO_3^{2-} < CO_2 < CO$
- (C) $CO < CO_2 < CO_3^{2-}$
- (D) $CO_2 < CO_3^{2-} < CO$

58. In which of the following molecules are all the bonds not equal ?

- (A) ClF_3
- (B) BF_3
- (C) AlF_3
- (D) NF_3

59. The electronegativity difference between N and F is greater than that between N and H yet the dipole moment of NH_3 (1.5 D) is larger than that of NF_3 (0.2 D). This is because :

- (A) in NH_3 as well as in NF_3 the atomic dipole and bond dipole are in the same direction
- (B) in NH_3 the atomic dipole and bond dipole are in the same direction whereas in NF_3 these are in opposite directions
- (C) in NH_3 as well as NF_3 the atomic dipole and bond dipole are in opposite directions
- (D) in NH_3 the atomic dipole and bond dipole are in the opposite directions whereas in NF_3 these are in the same directions

60. Which of the following species has a linear shape ?

- (A) NO_2^-
- (B) SO_2
- (C) NO_2^+
- (D) O_3

AIPMT 2006 Prelims · Q96

61. Which of the following is not a correct statement ?

- (A) The electron-deficient molecules can act as Lewis acids
- (B) The canonical structures have no real existence
- (C) Every AB_5 molecule does in fact have square pyramid structure
- (D) Multiple bonds are always shorter than corresponding single bonds

AIPMT 2006 Prelims · Q97

62. The number of unpaired electrons in a paramagnetic diatomic molecule of an element with atomic number 16 is :

- (A) 2
- (B) 3
- (C) 4
- (D) 1

AIPMT 2006 Prelims · Q99

63. Which of the following is not isostructural with $SiCl_4$?

- (A) SCl_4
- (B) SO_4^{2-}
- (C) PO_4^{3-}
- (D) NH_4^+

AIPMT 2005 Prelims · Q56

64. The correct order in which the O — O bond length increases in the following is :

- (A) $H_2O_2 < O_2 < O_3$
- (B) $O_3 < H_2O_2 < O_2$
- (C) $O_2 < O_3 < H_2O_2$
- (D) $O_2 < H_2O_2 < O_3$

AIPMT 2005 Prelims · Q62

65. Which of the following molecules has trigonal planar geometry ?

- (A) IF_3
- (B) PCl_3
- (C) NH_3
- (D) BF_3

AIPMT 2005 Prelims · Q68

66. The correct sequence of increasing covalent character is represented by :

- (A) $LiCl < NaCl < BeCl_2$
- (B) $BeCl_2 < NaCl < LiCl$
- (C) $NaCl < LiCl < BeCl_2$
- (D) $BeCl_2 < LiCl < NaCl$

AIPMT 2005 Prelims · Q81

67. Which of the following would have a permanent dipole moment ?

- (A) BF_3
- (B) SiF_4
- (C) SF_4
- (D) XeF_4

AIPMT 2005 Prelims · Q90

68. Which one of the following oxides is expected to exhibit paramagnetic behaviour ?

- (A) CO_2
- (B) SO_2
- (C) ClO_2
- (D) SiO_2

Answer key and explanations

1. Answer: (C) sp^2 and 6

Boron in BF_3 forms three σ bonds and has no lone pair, so it is sp^2 hybridised and trigonal planar. It has only 6 electrons in its valence shell, which is why it is electron deficient; 8 would complete the octet.

2. Answer: (A) (a)-(iv), (b)-(iii), (c)-(i), (d)-(ii)

PCl_5 : 5 bond pairs, trigonal bipyramidal. SF_6 : 6 bond pairs, octahedral. BrF_5 : 5 bond pairs + 1 lone pair, square pyramidal. BF_3 : 3 bond pairs, trigonal planar.

3. Answer: (C) $SbCl_5$

$SbCl_5$ is trigonal bipyramidal with five identical Sb-Cl bonds, so the bond dipoles cancel and the molecule is non-polar. $POCl_3$ (unequal P=O and P-Cl bonds), CH_2O (trigonal planar with C=O) and bent NO_2 all have net dipoles.

4. Answer: (A) He_2

He_2 would have the configuration $\sigma 1s^2 \sigma^* 1s^2$, so its bond order is $(2 - 2)/2 = 0$ and no stable molecule forms. Li_2 , C_2 and O_2 all have positive bond orders (1, 2 and 2), so they exist.

5. Answer: (D) Boron trifluoride, beryllium difluoride, carbon dioxide,

1,4-dichlorobenzene

BF_3 (trigonal planar), BeF_2 and CO_2 (linear) and 1,4-dichlorobenzene (para-substituted) are symmetric, so their bond dipoles cancel. Ammonia, water, NF_3 , HF and 1,3-dichlorobenzene all have a net dipole, so every other set contains at least one polar molecule.

6. Answer: (C) C_2

C_2 (12 electrons) has configuration $\sigma 1s^2 \sigma^* 1s^2 \sigma 2s^2 \sigma^* 2s^2 (\pi 2p_x^2 = \pi 2p_y^2)$; its bond order of 2 comes from the two π bonding pairs only, with no $\sigma 2p$ electrons. N_2 and O_2 contain a $\sigma 2p$ bond in addition to π bonds, and Be_2 has no net bond.

7. Answer: (B) two

Cl has 7 valence electrons; 3 form bonds with F, leaving 4 electrons = 2 lone pairs. Five electron pairs give a trigonal bipyramidal arrangement with the two lone pairs equatorial, hence the T-shape.

8. Answer: (B) CN^-

By MO theory: CN^- (14 electrons) has bond order 3; CN (13) and NO (15) have 2.5; CN^+ (12) has 2. So CN^- has the highest bond order; removing an electron from CN lowers it.

9. Answer: (D) Mg_3X_2

X is nitrogen, which gains 3 electrons to form N^{3-} , while Mg forms Mg^{2+} . Charge balance requires 3 Mg^{2+} for 2 N^{3-} , giving Mg_3X_2 (magnesium nitride). Mg_2X_3 reverses the subscripts.

10. Answer: (C) IBr_2^- , XeF_2

XeF_2 and IBr_2^- both have 22 valence electrons ($8 + 14$ and $7 + 14 + 1$) and both have three lone pairs on the central atom with two bonds, giving a linear shape. $BeCl_2$ is linear but has only 16 valence electrons, and TeI_2 is bent.

11. Answer: (D) BCl_3

BCl_3 has sp^2 boron with no lone pair, so it is trigonal planar with 120° angles. PH_3 and NCl_3 are pyramidal (angles below 109.5°) and ClF_3 is T-shaped (angles near 90°).

12. Answer: (C) CN^- , CO

CN^- and CO are both 14-electron species, isoelectronic with N_2 , so each has bond order 3. NO has 2.5 against 3 for CO, O_2 has 2 against 3 for NO^+ , and O_2^- has 1.5 against 3 for N_2 .

13. Answer: (C) H_2O

Oxygen is the smallest and most electronegative central atom, so the bonding pairs sit close to it and repel strongly, keeping the angle near 104.5° . Down the group the bonding pairs move away and the angle falls towards 90° (H_2S about 92° , H_2Te about 90°).

14. Answer: (B) ClO_3^- , CO_3^{2-}

ClO_3^- has three bond pairs and one lone pair on Cl (sp^3), so it is trigonal pyramidal, whereas CO_3^{2-} is sp^2 trigonal planar. ICl_4^- and XeF_4 are both square planar, IBr_2^- and XeF_2 both linear, and BrO_3^- and XeO_3 both pyramidal.

15. Answer: (C) sp , sp^2 and sp^3

NO_2^+ is linear with two σ bonds and no lone pair on N (sp). NO_3^- is trigonal planar with three σ bonds (sp^2). NH_4^+ is tetrahedral with four σ bonds (sp^3). So the sequence is sp , sp^2 , sp^3 .

16. Answer: (D) square planar, sp^3d^2

Xe in XeF_4 has 4 bond pairs and 2 lone pairs, six electron pairs in all, so it is sp^3d^2 hybridised. The electron-pair arrangement is octahedral, but with the two lone pairs opposite each other the shape of the molecule is square planar.

17. Answer: (B) The H-O-H bond angle in H₂O is larger than the H-C-H bond angle in CH₄.

All three are sp³ hybridised, with bond angles CH₄ 109.5° > NH₃ 107° > H₂O 104.5°, because lone pairs repel bonding pairs more strongly. So the claim that water's angle exceeds methane's is false; all three angles are still above 90°.

18. Answer: (A) lone pair - lone pair > lone pair - bond pair > bond pair - bond pair

According to VSEPR theory, lone pairs are held only by one nucleus and spread out more, so they repel most strongly. The repulsion order is lone pair-lone pair > lone pair-bond pair > bond pair-bond pair, which is why lone pairs compress bond angles in NH₃ and H₂O.

19. Answer: (A) XeF₆ - distorted octahedral; XeO₃ - pyramidal; XeOF₄ - square pyramidal; XeF₄ - square planar

XeF₆ (sp³d³, 6 bond pairs + 1 lone pair) is distorted octahedral; XeO₃ (sp³, 3 bond pairs + 1 lone pair) is pyramidal; XeOF₄ (sp³d², 5 bond pairs + 1 lone pair) is square pyramidal; XeF₄ (sp³d², 4 bond pairs + 2 lone pairs) is square planar. A square planar XeO₃ is impossible because its lone pair makes it pyramidal.

20. Answer: (B) 18 sigma bonds and 2 pi - bonds

CH₃-C(OH)=CH-COOC₂H₅ has 9 C-H, 4 C-C, 4 C-O and 1 O-H σ bonds = 18 σ bonds, and two π bonds (one C=C, one C=O). 9 σ bonds counts only the skeleton without hydrogens.

21. Answer: (C) XeO₄

XeO₄ has four Xe-O σ bonds and four π bonds (each Xe=O is one σ + one π). CH₂(CN)₂ has 6 σ and 4 π, (CN)₂ has 3 σ and 4 π, and HCO₃⁻ has 4 σ and 1 π.

22. Answer: (A) O₂⁻ < O₂⁺ < O₂²⁺

By MO theory O₂ has bond order 2; removing antibonding electrons raises it: O₂⁺ = 2.5, O₂²⁺ = 3, while adding one gives O₂⁻ = 1.5. So O₂⁻ < O₂⁺ < O₂²⁺.

23. Answer: (A) ClO₃⁻, SO₃²⁻

ClO₃⁻ (17 + 24 + 1 = 42 electrons) and SO₃²⁻ (16 + 24 + 2 = 42) are isoelectronic, and both have three bond pairs and one lone pair, so both are pyramidal. CO₃²⁻ and NO₃⁻ are trigonal planar with 32 electrons.

24. Answer: (C) O₂⁻ < O₂ < O₂⁺

MO bond orders: O₂⁻ = 1.5, O₂ = 2, O₂⁺ = 2.5, because electrons are added to or removed from the π* antibonding orbitals. Hence O₂⁻ < O₂ < O₂⁺.

25. Answer: (D) NO₂⁺

NO₂⁺ is isoelectronic with CO₂ and is linear (180°). NO₃⁻ is trigonal planar (120°), NO₂ is bent (~134°) and NO₂⁻ is bent (~115°) due to the lone pair.

26. Answer: (A) Ethyne

Carbon in CO₂ is sp hybridised. Ethyne carbons are also sp, whereas ethene carbons are sp² and ethane/ethanol carbons are sp³.

27. Answer: (A) NO₃⁻

In NO₃⁻ the nitrogen has three bond pairs and no lone pair (sp²), giving a trigonal planar shape. NO₂⁻ has a lone pair and is bent, while CO₂ and N₃⁻ are linear.

28. Answer: (B) NH₃

In NH₃ the lone-pair moment and the N-H bond moments point the same way, giving about 1.47 D. In NF₃ the N-F bond moments oppose the lone pair (about 0.23 D), and CH₄ and CO₂ are non-polar.

29. Answer: (B) O₂⁻

CO, CN⁻ and NO⁺ are isoelectronic with 14 electrons and have all electrons paired. O₂⁻ has 17 electrons, with one unpaired electron in a π* orbital, so it is paramagnetic.

30. Answer: (B) ICl₂⁻

XeF₂ has 5 electron pairs (2 bond pairs, 3 lone pairs), sp³d, and is linear. ICl₂⁻ also has 2 bond pairs and 3 lone pairs, so it is linear too. TeF₂ is bent and SbCl₃ is pyramidal; BaCl₂ is an ionic solid.

31. Answer: (C) (BH₃)₂

(BH₃)₂ is diborane, B₂H₆. Each boron has only three valence electrons, so the molecule lacks enough electrons for normal two-electron bonds and uses 3-centre-2-electron B-H-B bonds: it is electron deficient. Ethane, disilane and PH₃ have complete octets.

32. Answer: (B) H₂O

H₂O has only two O-H σ bonds. CO₂ (O=C=O), SO₂ and NO₂ all contain double-bond character and so π bonds.

33. Answer: (B) SF₄

SF₄ has four bond pairs and one lone pair (see-saw shape), so its bond dipoles do not cancel and it is polar. BF₃ (trigonal planar), SiF₄ (tetrahedral) and XeF₄ (square planar) are symmetric, so they are non-polar.

34. Answer: (A) π^* orbital

In O₂ the two π^*2p orbitals each hold one electron, and they are the lowest vacant-capacity orbitals, so the extra electron of O₂⁻ enters a π^* orbital. The bonding π and σ orbitals are already full.

35. Answer: (D) He₂⁺ < O₂⁻ < NO < C₂²⁻

Bond orders from MO theory: He₂⁺ = 0.5, O₂⁻ = 1.5, NO = 2.5 and C₂²⁻ = 3 (isoelectronic with N₂). So the increasing order is He₂⁺ < O₂⁻ < NO < C₂²⁻.

36. Answer: (A) BF₄⁻ and NH₄⁺

In BF₄⁻ and NH₄⁺ the central atom has four bond pairs and no lone pair: sp³, tetrahedral. BCl₃ is trigonal planar while BrCl₃ is T-shaped; NH₃ is pyramidal while NO₃⁻ is trigonal planar; NF₃ is pyramidal while BF₃ is planar.

37. Answer: (C) O₂⁻

By MO theory, O₂⁻ has 10 bonding and 7 antibonding electrons (valence), bond order = (10 - 7)/2 = 1.5. O₂ is 2, O₂⁺ is 2.5 and O₂²⁻ is 1.

38. Answer: (B) O₂²⁻, B₂

O₂²⁻ (18 electrons) has bond order 1 and B₂ (10 electrons) also has bond order 1. N₂ = 3 vs O₂ = 2; O₂⁺ = 2.5 vs NO⁺ = 3; NO = 2.5 vs CO = 3.

39. Answer: (A) PCl₃

P in PCl₃ has 5 valence electrons: three form bonds with Cl and two remain as one lone pair (pyramidal). H₂O and NH₂⁻ each have two bond pairs and two lone pairs, and BF₃ has three bond pairs and no lone pair.

40. Answer: (A) O₂⁺, O₂ - Both paramagnetic

By MO theory O₂ has 2 unpaired electrons and O₂⁺ has 1, so both are paramagnetic. O₂²⁻ has all electrons paired (diamagnetic), so the pairings with peroxide as paramagnetic are wrong, and O₂⁻ has 1 unpaired electron, so calling it diamagnetic is wrong.

41. Answer: (B) C-H < C=C < C-O < C-C

Typical bond lengths: C-H ≈ 109 pm, C=C ≈ 134 pm, C-O ≈ 143 pm, C-C ≈ 154 pm. So the increasing order is C-H < C=C < C-O < C-C. A double bond is shorter than any of the carbon single bonds to C or O.

42. Answer: (D) BF₃

A Lewis base donates an electron pair. OH⁻, H₂O and NH₃ all have lone pairs, whereas BF₃ has an incomplete octet on boron and accepts a pair, so it is a Lewis acid and least likely to act as a base.

43. Answer: (B) O₂⁺

MO bond orders: O₂⁺ 2.5, O₂ 2, O₂⁻ 1.5, O₂²⁻ 1. Bond length decreases as bond order increases, so O₂⁺ has the shortest bond. Adding electrons fills π^* orbitals and lengthens the bond.

44. Answer: (B) SF₄

SF₄ has 4 bond pairs and 1 lone pair on S (5 electron pairs), so S is sp³d with a see-saw shape. CH₄, BF₄⁻ and NH₄⁺ all have four electron pairs and are sp³.

45. Answer: (A) Dissimilar in hybridization for the central atom with different structures

In NO₃⁻ nitrogen has three σ -bonds and no lone pair, so it is sp² and trigonal planar. In H₃O⁺ oxygen has three bonds and one lone pair, so it is sp³ and pyramidal. Thus both the hybridization and the shapes differ; they are not isostructural.

46. Answer: (C) Be₂

Be₂ has 8 electrons: $\sigma 1s^2 \sigma^* 1s^2 \sigma 2s^2 \sigma^* 2s^2$, bond order (4 - 4)/2 = 0, so it does not exist. Li₂ (bond order 1), Be₂⁺ (bond order ½) and B₂ (bond order 1) have positive bond orders.

47. Answer: (C) BF₃ and NO₂⁻

BF₃ has 3 bond pairs and no lone pair (sp²); NO₂⁻ has 2 bond pairs and 1 lone pair on N (sp²). NH₂⁻, NH₃ and H₂O each have 4 electron pairs on the central atom and are sp³.

48. Answer: (D) SbCl₅²⁻

PCl₅ (5 bond pairs), SF₄ (4 bp + 1 lp) and I₃⁻ (2 bp + 3 lp) all have 5 electron pairs: sp³d. SbCl₅²⁻ has Sb(III) with 5 bond pairs and 1 lone pair, 6 pairs: sp³d², so it is the odd one out.

49. Answer: (D) B₂H₆

B₂H₆ is electron-deficient (each B has an incomplete octet) and accepts electron pairs, so it acts as a Lewis acid. CH₄ is electron-precise, while NH₃ and H₂O have lone pairs and act as Lewis bases.

50. Answer: (D) Hydrogen bonding

Methanol molecules are linked by O-H...O hydrogen bonds, which are the dominant forces to be overcome on boiling. Covalent bonds are broken only in a chemical change, and dipole-dipole and London forces are present but weaker.

51. Answer: (A) N₂²⁻ < N₂⁻ < N₂

N₂ (14 electrons) has bond order 3. Each extra electron enters an antibonding π* orbital and lowers the bond order by ½: N₂⁻ = 2.5, N₂²⁻ = 2. Increasing order: N₂²⁻ < N₂⁻ < N₂.

52. Answer: (C) BF₃ and NO₂⁻

BF₃ has three bond pairs and no lone pair, and NO₂⁻ has two σ bonds and one lone pair on N; both have three electron domains, so sp². NH₂⁻ and H₂O each have two bond pairs and two lone pairs (four domains), so they are sp³.

53. Answer: (A) 2 sigma and 1 pi bond

Ozone has two O-O σ bonds forming the bent skeleton, and one π bond that is delocalised over the three atoms by resonance (each O-O has bond order 1.5). Two π bonds would require one O=O on each side, which is not the structure.

54. Answer: (C) NO₂⁻ < NO₂ < NO₂⁺

NO₂⁺ has no non-bonding electrons on N and is linear (180°). NO₂ has a single unpaired electron on N (about 134°), and NO₂⁻ has a full lone pair that repels more strongly (about 115°). So the increasing order is NO₂⁻ < NO₂ < NO₂⁺. The reverse order wrongly treats the linear cation as the most bent.

55. Answer: (A) He₂⁺ < O₂⁻ < NO < C₂²⁻

From MO theory: He₂⁺ (3 e⁻) has bond order 0.5, O₂⁻ (17 e⁻) 1.5, NO (15 e⁻) 2.5, and C₂²⁻ (14 e⁻, like N₂) 3. The increasing order is He₂⁺ < O₂⁻ < NO < C₂²⁻. Placing He₂⁺ last mistakes its weak half bond for a strong one.

56. Answer: (C) BrO₃⁻ and XeO₃

BrO₃⁻ and XeO₃ each have three bond pairs and one lone pair on the central atom, so both are trigonal pyramidal. SO₃²⁻ is pyramidal but NO₃⁻ is planar; BF₃ is planar but NF₃ pyramidal; SF₄ is see-saw but XeF₄ square planar.

57. Answer: (C) CO < CO₂ < CO₃²⁻

C-O bond order is about 3 in CO, 2 in CO₂ and 1½ in CO₃²⁻ (resonance). Higher bond order means a shorter bond, so CO < CO₂ < CO₃²⁻.

58. Answer: (A) ClF₃

ClF₃ has 3 bond pairs and 2 lone pairs on Cl (sp³d), giving a T shape with two longer axial Cl-F bonds and one shorter equatorial bond. BF₃ and AlF₃ are trigonal planar and NF₃ is pyramidal, each with three identical bonds.

59. Answer: (B) in NH₃ the atomic dipole and bond dipole are in the same direction whereas in NF₃ these are in opposite directions

In NH₃ the lone pair's orbital dipole points away from N, the same way as the N-H bond dipoles (towards N), so they add up to 1.5 D. In NF₃ the N-F bond dipoles point towards the F atoms, opposite to the lone-pair dipole, so they largely cancel, leaving only 0.2 D.

60. Answer: (C) NO₂⁺

NO₂⁺ has two bond pairs and no lone pair on N (sp hybridised), like the isoelectronic CO₂, so it is linear. NO₂⁻, SO₂ and O₃ each have a lone pair on the central atom and are bent.

61. Answer: (C) Every AB₅ molecule does in fact have square pyramidal structure

AB₅ molecules with no lone pair, such as PCl₅, are trigonal bipyramidal; only those with a lone pair (AB₅E, e.g. BrF₅) are square pyramidal. So the claim that every AB₅ molecule is square pyramidal is false. The other three statements are standard facts.

62. Answer: (A) 2

Z = 16 is sulphur. S₂ is isoelectronic in its valence shell with O₂, and its two highest electrons occupy the two degenerate π* orbitals singly (Hund's rule). So S₂ has 2 unpaired electrons and is paramagnetic.

63. Answer: (A) SCl₄

SiCl₄, SO₄²⁻, PO₄³⁻ and NH₄⁺ all have four bond pairs and no lone pair on the central atom, so they are tetrahedral. SCl₄ has four bond pairs and one lone pair on S (sp³d), giving a see-saw shape, so it is not isostructural.

64. Answer: (C) $O_2 < O_3 < H_2O_2$

O-O bond order: $O_2 = 2$, $O_3 = 1.5$ (resonance), $H_2O_2 = 1$. Bond length increases as bond order decreases, so $O_2 < O_3 < H_2O_2$.

65. Answer: (D) BF_3

BF_3 has three bond pairs and no lone pair on boron (sp^2), so it is trigonal planar. PCl_3 and NH_3 are pyramidal (one lone pair) and IF_3 is T-shaped (two lone pairs).

66. Answer: (C) $NaCl < LiCl < BeCl_2$

By Fajans' rules, a smaller, more highly charged cation polarises Cl^- more. Polarising power $Na^+ < Li^+ < Be^{2+}$, so covalent character $NaCl < LiCl < BeCl_2$.

67. Answer: (C) SF_4

SF_4 has 4 bond pairs and 1 lone pair (see-saw), so its bond dipoles do not cancel. BF_3 (trigonal planar), SiF_4 (tetrahedral) and XeF_4 (square planar) are symmetric with zero net dipole.

68. Answer: (C) ClO_2

ClO_2 has an odd number of electrons (33), so it has an unpaired electron and is paramagnetic. CO_2 , SO_2 and SiO_2 have all electrons paired.

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