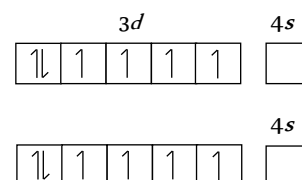


AS Answers and Solutions

Electrovalent bonding

1. (b) NaCl is ionic crystal so it is formed by Na^+ and Cl^- ions.
2. (a) Bond formation is always exothermic. Compounds of sodium are ionic.
3. (a) According to Fajan's rule ionic character is less.
4. (c) Valencies of L , Q , P and R is -2 , -1 , $+1$ and $+2$ respectively so they will form P_2L , RL , PQ and RQ_2 .
5. (c) Electrovalent compounds are good conductor of heat and electricity in molten state or in aqueous solution.
7. (d) Electrovalent bond formation depends on ionization energy of cation, electron affinity of anion and on lattice energy.
8. (b) Because CsF is electrovalent compound.
9. (c) NaCl is formed by electrovalent bonding.
10. (d) Valency of metal is $+2$ by formula MO so its phosphate would be $M_3(\text{PO}_4)_2$ because valency of $[\text{PO}_4]$ is -3 .
11. (b) Li , Na and K are alkali metals with low ionization energy and one electron in their outermost shell so they will form cation easily.
12. (a) Melting point and boiling point of electrovalent compounds are high due to strong electrostatic force of attraction between the ions.
13. (d) The value of lattice energy depends on the charges present on the two ions and distance between them. It shall be high if charges are high and ionic radii are small.
14. (a) Cs is more electropositive.
15. (a) X loses electron, Y gains it.
16. (c) Formation of NaCl occurs by Na_{ion}^+ and Cl_{ion}^- .
17. (b) MgCl_2 has electrovalent linkage because magnesium is electropositive metal while chlorine is electronegative.
18. (a) Electrovalent compounds generally have high m.pt and high b.pt due to stronger coulombic forces of attractions.
19. (d) Water is a polar solvent so it decreases the interionic attraction in the crystal lattice due to solvation.
20. (c) Element C has electronic structure $1s^2, 2s^2 2p^5$, it requires only one electron to complete its octet and it will form anion so it will form electrovalent bond.
21. (b) Since the chloride of a metal is MCl_2 therefore metal ' M ' must be divalent i.e. M^{2+} . As a result the formula of its phosphate is $M_3(\text{PO}_4)_2$.
22. (d) In MPO_4 the oxidation state of M is $+3$. Hence, the formula of nitrate is $M(\text{NO}_3)_3$.
23. (a) Ion is formed by gaining or losing electrons. To form cation electron are lost from the valency shell, so Zn atoms to Zn^{++} ions there is a decrease in the no. of valency electron.
24. (a) $M_3(\text{PO}_4)_2$ means M is divalent so formula of its sulphate is MSO_4 .
25. (b) As the molecular formula of chloride of a metal M is MCl_3 , it is trivalent so formula of its carbonate will be $M_2(\text{CO}_3)_3$.
26. (d) Sodium chloride is electrovalent compound so it dissolves in water which is a polar solvent.
27. (d) When sodium chloride is dissolved in water, the sodium ion is hydrated.
30. (d) Yet the formula of sulphate of a metal (M) is $M_2(\text{SO}_4)_3$, it is M^{3+} ion so formula of its phosphate would be MPO_4 .
32. (b) Molten sodium chloride conducts electricity due to the presence of free ions.
33. (b) The phosphate of a metal has the formula MHPO_4 it means metal is divalent so its chloride would be MCl_2 .
34. (d)
35. (b) Cs is highly electropositive while F is highly electronegative so they will form ionic bond.
37. (b) Na is highly electropositive while Cl is highly electronegative so they will form ionic bond.
38. (a) Ionic compounds are good conductors of heat and electricity so they are good electrolyte.
39. (a) Metal tends to lose electrons due to low ionization energy.
40. (c) As the formula of calcium pyrophosphate is $\text{Ca}_2\text{P}_2\text{O}_7$ means valency of pyrophosphate radical is -4 so formula of ferric pyrophosphate is $\text{Fe}_4(\text{P}_2\text{O}_7)_3$.
41. (c) $M-X$ bond is a strongest bond so between $\text{Na}-\text{Cl}$ is a strongest bond.
42. (b) The solubility order is : $\text{BeF}_2 > \text{MgF}_2 > \text{CaF}_2 > \text{SrF}_2$ so SrF_2 is least soluble.
43. (d) NaF has maximum melting point, melting point decreases of sodium halide with increase in size of halide their bond energy get lower.
44. (b) Sulphanilic acids have bipolar structure so their melting point is high and insoluble in organic solvents.
45. (c) CaCl_2 will have electrovalent bonding because calcium is electropositive metal while chlorine is electronegative so they will combined with electrovalent bond.
47. (a) Electrovalent bond is formed by losing electrons from one atom and gaining electron by other atom i.e. redox reaction.
48. (b) Electrovalent compound are polar in nature because they are formed by ions.
50. (b) CsCl has ionic bonding.
51. (b) As soon as the electronegativity increases, ionic bond strength increases.
52. (b) This X element is a second group element so its chloride will be XCl_2 .
53. (a) When electronegativity difference is from 1.7 to 3.0. This bond is called as ionic bond.
54. (a) Ethyl chloride is an organic compound so it will be covalent.
55. (a) Lithium oxide and calcium fluoride show ionic characters.
57. (a) Generally cation and anion form ionic bond.
58. (c) Those atoms which contain $+ve$ and $-ve$ sign are known as ion.
59. (a) Generally Br-F contain maximum electronegativity difference compare to other compound.
61. (a) Due to greater electronegativity difference.



62. (b) $Co^{3+} = 3d^6 4s^0$,

$$Ni^{4+} = 3d^6 4s^0,$$

64. (d) $BaCl_2$ contain higher ionic character.

66. (a) Electrolytes are compound which get dissociated into their ion in water so it contains electrovalent bond.

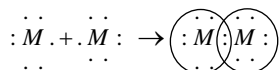
67. (abc) CaH_2, BaH_2, SrH_2 are ionic hydride.

68. (bcd) Generally $MgCl_2, SrCl_2, BaCl_2$ are ionic compounds so they conduct electricity in fused state.

Covalent bonding

2. (c) In N_2 molecule each Nitrogen atom contribute $3e^-$ so total no. of electron's are 6.

3. (b) Non-metals readily form diatomic molecules by sharing of electrons. Element $M(1s^2 2s^2 2p^5)$ has seven electrons in its valence shell and thus needs one more electron to complete its octet. Therefore, two atoms share one electron each to form a diatomic molecule (M_2)

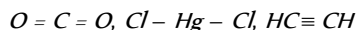


5. (d) Covalent character depend on the size of cation and anion.

6. (a) In graphite all carbon atoms are sp^2 -hybridised and have covalent bond.

7. (c) Silica has tendency to form long chain covalent structure such as carbon so it has giant covalent structure.

8. (a) All have linear structure.



9. (d) Similar atoms form covalent bond.

10. (a) Covalent bond forms when electronegativity difference of two atom is equal to 1.7 or less than 1.7

11. (b) Similar atoms form covalent bond.

12. (b) Water is a polar solvent while covalent compounds are non-polar so they usually insoluble in water.

13. (c) BCl_3 is electron deficient compound because it has only '6' electrons after forming bond.

14. (b) Due to its small size and 2 electrons in s -orbital Be forms covalent compound.

18. (c) H_2O will formed by covalent bonding.

21. (a) Two identical atoms are joined with covalent bond so H_2 will be covalent.

23. (c) Element 'X' has atomic no. 7 so its electronic configuration will be 2, 5. So its electron dot symbol would be $\cdot\dot{X}\cdot$.

24. (c) $C-S$ will be most covalent. Covalent character depend on the size of cation and anion.

25. (c) HCl has ionic character yet it has covalent compound because electronegativity of chlorine is greater than that of hydrogen.

26. (c) Order of polarising power $Be^{++} > Li^+ > Na^+$
Hence order of covalent character $BeCl_2 > LiCl > NaCl$.

31. (b) Valency of phosphorus in H_3PO_4 is supposed 'x' then $3 + x - 8 = 0, x - 5 = 0, x = 5$.

33. (d) $(+1) + x + 3(-2) = 0 \Rightarrow 1 + x - 6 = 0 \Rightarrow x = 6 - 1 = 5$.

34. (a) HCl molecule has covalent bond.

35. (d) Electrovalent compounds have high melting point and high boiling point.

36. (b) Middle length of $H_2 = 74 pm$

$$\text{Length of } H = \frac{74}{2} = 37 pm$$

$$\text{Middle length of } Cl_2 = 198 pm$$

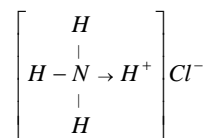
$$\text{Length of } Cl = \frac{198}{2} = 99 pm$$

$$\begin{aligned} \text{Bond length of } HCl &= \text{Length of } H + \text{Length of } Cl \\ &= 37 + 99 = 136 pm \end{aligned}$$

37. (d) Compound has 254 gm of I_2 means $\frac{254}{127} = 2$ mole, while

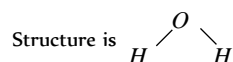
80 gm O_2 means $\frac{80}{16} = 5$ mole so they will form compound I_2O_5 .

38. (c) NH_4Cl has covalent as well as ionic bond.



39. (d) Covalent character increases when we come down a group so CaI_2 will have highest covalent character.

41. (b) In water molecule three atom are linked by covalent bond.



42. (b) $:N \equiv N^+ - \ddot{O}:^-$ or $N \equiv N \rightarrow O$.

44. (b) The electronic configuration of $Na(Z=11)$ is $1s^2, 2s^2 2p^6, 3s^1$. The oxide of Na is Na_2O .

45. (b) Covalent bond is directional.

47. (d) Bond dissociation energy decreases with increase in size. So D is smallest.

48. (b) Molecule X is nitrogen because nitrogen molecule has triple bond. It's configuration will be $1s^2, 2s^2 2p^3$.

49. (a) PCl_5 does not follow octet rule, it has 10 electrons in its valence shell.

50. (a) The compound will be A_2B_3 (By criss cross rule).

51. (b) Each nitrogen share 3 electrons to form triple bond.

52. (d) Urea solution does not conduct electricity because it is a covalent compound.

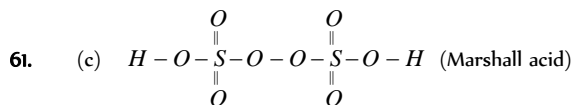
54. (d) Due to the small size and higher ionization energy, boron forms covalent compound.

58. (a) BF_3 contain 6 electron so it is lewis acid.

59. (d) Among the given species. The bond dissociation energy of $C-O$ bond is minimum in case of CO_3^{2-} by which

$C-O$ bond become more weaker in CO_3^{2-} or the bond order of CO_3^{2-} (1.33) is minimum so the bond become weaker.

60. (a) Valency of $Na_2S_2O_3$ is supposed to be x , then $2 + 2x + (-6) = 0$, $2x - 4 = 0$, $x = 2$.

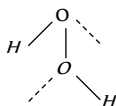


62. (a) Among the given choice Al is least electropositive therefore, the bond between Al and Cl will be least ionic or most covalent or the difference in electronegativity of two atom is less than 1.8.
63. (b) Electronic configuration of $_{16}S^{32} = 1s^2, 2s^2, 2p^6, 3s^2, 3p^4$. In the last orbit it has only 6 electron. So it require 2 electron to complete its octet, therefore it share 2 electron with two hydrogen atom and forms 2 covalent bond with it.
64. (b) The acidity of hydrides of VI group elements increase from top to bottom as the bond strength $X-H$ decrease from top to bottom
 $H_2O < H_2S < H_2Se < H_2Te$

65. (b) We know that Al^{3+} cation is smaller than Na^+ (because of greater nuclear charge) According to Fajan's rule, small cation polarise anion upto greater extent. Hence Al^{3+} polarise Cl^- ion upto greater extent, therefore $AlCl_3$ has covalent bond between Al and Cl atoms.

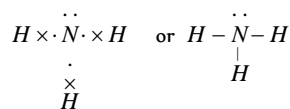
66. (b) Sulphur has the second highest catenation property after carbon. Its molecule has eight atom bonded together (i.e. S_8)

67. (b) H_2O_2 has open book structure.



69. (b) The electronic configuration of nitrogen is ${}_7N = 1s^2, 2s^2, 2p^3$

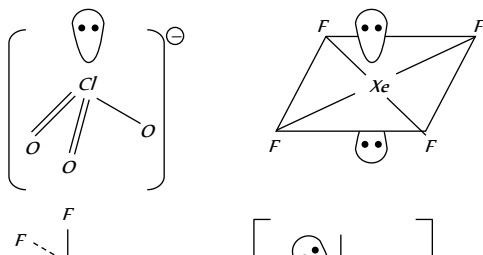
It has 5 electrons in valency shell, hence in ammonia molecule it complete its octet by sharing of three electron with three H atom, therefore it has 8 electrons in its valence shell in ammonia molecule



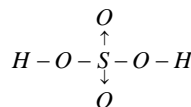
71. (c) Multiple bonds have more bond energy so $C \equiv N$ will be the strongest.
72. (c) Diamond, silicon and quartz molecule bounded by covalent bond.
73. (cd) C_2H_4 and N_2 has multiple bonds.
74. (ad) CO has only 6 electrons while PCl_5 has 10 electrons after sharing so both don't follow octet rule.
76. (a) Among these, NaH and CaH_2 are ionic hydrides and B_2H_6 and NH_3 are covalent hydrides.

Co-ordinate or Dative bonding

1. (d)



2. (b) H_2SO_4 has co-ordinate covalent bond.



3. (c) NH_3 has lone pair of electron while BF_3 is electron deficient compound so they form a co-ordinate bond.
 $NF_3 \rightarrow BF_3$

4. (d) HNO_2 does not have co-ordinate bond. Structure is $H-O-N=O$.

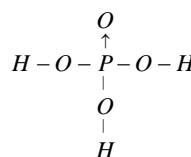
7. (a) Structure of N_2O_5 is $O=\overset{\downarrow}{N}-O-\overset{\downarrow}{N}=O$.

9. (a) SO_3^{2-} has one coordinate bond. $^-O-\overset{\downarrow}{S}-O^-$

10. (d) Co-ordinate bond is a special type of covalent bond which is formed by sharing of electrons between two atoms, where both the electrons of the shared pair are contributed by one atom. Since this type of sharing of electrons exists in O_3 , SO_3 and H_2SO_4 . Therefore all these contains coordinate bond.

12. (a) $CH_3N \equiv C$ contain dative bond.

13. (a) H_3PO_4 is orthophosphoric acid.

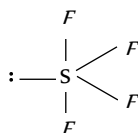


15. (c) Sulphuric acid contain, covalent and co-ordinate bond.

Dipole moment

1. (b) CO_2 is a symmetrical molecule so its dipole moment is zero.
2. (d) These all have zero dipole moment.
3. (d) HF has largest dipole moment because electronegativity difference of both is high so it is highly polar.
5. (c) Due to its symmetrical structure.
6. (c) Chloroform has 3 chlorine atom and one hydrogen atom attached to the carbon so it is polarised and it will show dipole moment.
8. (a) The dipole moment of two dipoles inclined at an angle θ is given by the equation $\mu = \sqrt{X^2 + Y^2 + 2XY \cos \theta}$
 $\cos 90^\circ = 0$. Since the angle increases from $90 - 180$, the value of $\cos \theta$ becomes more and more $-ve$ and hence resultant decreases. Thus, dipole moment is maximum when $\theta = 90^\circ$.

9. (c) Due to distorted tetrahedral geometry SF_4 has permanent dipole moment



10. (b) CCl_4 has no net dipole moment because of its regular tetrahedral structure.
12. (d) HF is polar due to difference of electronegativity of hydrogen and fluorine so it shows positive dipole moment.
14. (c) BCl_3 has zero dipole moment because of its trigonal planar geometry.
16. (c) Dipole moment of CH_3OH is maximum in it.
20. (b) CH_4 have regular tetrahedron so its dipole moment is zero.
22. (b) Ammonia have some dipole moment.
23. (b) Charge of $e^- = 1.6 \times 10^{-19}$

$$\text{Dipole moment of } HBr = 1.6 \times 10^{-30}$$

$$\text{Inter atomic spacing} = 1 \text{ \AA} = 1 \times 10^{-10} \text{ m}$$

% of ionic character in

$$HBr = \frac{\text{dipole moment of } HBr \times 100}{\text{interspace distance} \times q}$$

$$= \frac{1.6 \times 10^{-30}}{1.6 \times 10^{-19} \times 10^{-10}} \times 100$$

$$= 10^{-30} \times 10^{29} \times 100 = 10^{-1} \times 100 = 0.1 \times 100 = 10\%$$

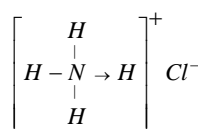
25. (a) Carbon tetrachloride has a zero dipole moment because of its regular tetrahedral structure.
27. (b) BF_3 has zero dipole moment.
29. (c) Given ionic charge $= 4.8 \times 10^{-10}$ e.s.u. and ionic distance $= 1 \text{ \AA} = 10^{-8} \text{ cm}$ we know that dipole moment = ionic charge \times ionic distance $= 4.8 \times 10^{-10} \times 10^{-8}$
 $= 4.8 \times 10^{-18}$ e.s.u. per cm $= 4.8$ debye.
30. (a) Higher is the difference in electronegativity of two covalently bonded atoms, higher is the polarity. In HCl there is high difference in the electronegativity of H and Cl atom so it is a polar compound.
31. (a) Linear molecular has zero dipole moment CO_2 has linear structure so it does not have the dipole moment $O=C=O$.
32. (c) SF_6 is symmetrical and hence non polar because its net dipole moment is zero.
33. (a) Polarity create due to the difference in electronegativity of both atom in a molecule except H_2 all other molecule have the different atom so they will have the polarity while H_2 will be non polar.
34. (bd) *cis* isomer shows dipole moment while that of *trans* is zero or very low value. *Trans* 1, 2 di-chloro-2-pentene will also show dipole moment due to unsymmetry.
35. (a) % of ionic character

$$= \frac{\text{Experimental value of dipole moment}}{\text{Expected value of dipole moment}}$$

$$= \frac{1.03}{6.12} \times 100 = 16.83\% \approx 17\%$$

Polarisation and Fajan's rule

- (d) BF_3 is planar while NF_3 is pyramidal due to the presence of lone pair of electron on nitrogen in NF_3 .
- (c) H_2O is a polar molecule due to electronegativity difference of hydrogen and oxygen.
- (b) When electronegativity difference is more between two joined atoms then covalent bond becomes polar and electron pair forming a bond don't remain in the centre.
- (d) Hexane has symmetrical structure so does not have polarity.
- (c) When two identical atoms form a bond, bond is non-polar.
- (a) According to Fajan's rule, polarisation of anion is influenced by charge and size of cation more is the charge on cation, more is polarisation of anion.
- (a) When two atoms shares two electrons it is an example of covalent bond. This covalent bond may be polar or may be non-polar depends on the electronegativity difference. In given example formula is AB . So it is polar.
- (c) HCl is most polar due to high electronegativity of Cl .
- (b) NH_3 has sp^3 hybridised central atom so it is non planar.
- (d) *p*-dichloro benzene have highest melting point.
- (b) NH_4Cl has both types of bonds polar and non polar

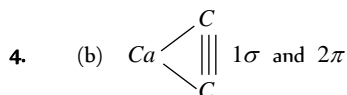


- (b) Greater the charge of cation more will be its polarising power (according to Fajan's rule).
- (d) AlI_3 Aluminium triiodide shows covalent character. According to Fajan's rule.
- (d) As the size of anion increases, polarity character increases.
- (d) Due to the electronegativity difference.
- (a) We know that greater the difference in electronegativity of two atoms forming a covalent bond. More is its polar nature. In HF there is a much difference in the electronegatives of hydrogen and fluorine. Therefore (HF) is a polar compound.
- (c) Silicon tetrafluoride has a centre of symmetry.
- (d) BF_3 have zero dipole moment.
- (b) According to Fajan's rule largest cation and smallest anion form ionic bond.
- (b) Polarity character is due to the difference in electronegativity of two atoms or molecule.

Overlapping- σ and π bonds

- (c)
- (c) In fluorine molecule formation *p-p* orbitals take part in bond formation.

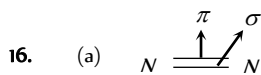
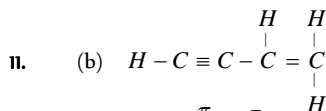
3. (b) π -bond is formed by lateral overlapping of unhybridised p - p orbitals.



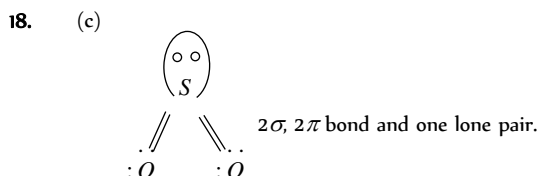
5. (c) In a double bond connecting two atom sharing of 4 electrons take place as in $\text{H}_2\text{C} = \text{CH}_2$.

6. (c) $\text{C} \equiv \text{C}$ is a multiple bond so it is strongest.

9. (d) As the bond order increases, $\text{C}-\text{H}$ bond energy also increases so it will be greatest in acetylene because its B.O. is 3.

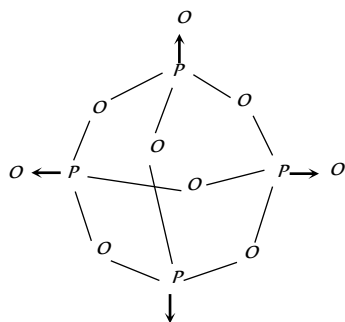


17. (d) We know that trisilylamine is sp^2 -hybridized therefore $p\pi-d\pi$ bonding is possible due to the availability of vacant d -orbitals with silicon.



19. (d) $\text{:}\ddot{\text{O}} = \text{S} = \ddot{\text{O}}\text{:}$ 5 atoms has 12 electrons in its outermost shell. One $(\text{S}-\text{O})\pi$ bond will be $(p-p)$ π bond while two $(\text{S}-\text{O})\pi$ bond will be $(p-d)$ π bond.

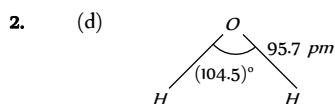
20. (d) Structure of P_4O_{10} is



Each phosphorus is attached to 4 oxygen atoms.

Hybridisation

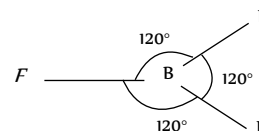
1. (d) H_2O is not linear because oxygen is sp^3 hybridised in H_2O .



4. (c) CO_2 has sp -hybridization and is linear.

5. (d) $\text{No. of } e \text{ pair} = 3 + \frac{1}{2}[3 - 3] = 0$

$\text{No. of } e \text{ pair} = 3 + 0$



$\text{No. of atom bonded to the central atom} = 3$

In case of 3, 3 geometry is Trigonal planar.

6. (a) In sp^3 -hybridisation each sp^3 hybridised orbital has $1/4$ s -character.

8. (b) In ethylene both Carbon atoms are sp^2 -hybridised so 120° .

9. (d) Structure of sp^3d hybridized compound is Trigonal bipyramidal.

10. (d) In $\text{H}-\text{C} \equiv \overset{\text{O}}{\underset{*}{\text{C}}}-\text{O}-\text{H}$ the asterisked carbon has a valency of

5 and hence this formula is not correct.

11. (d) dsp^3 hybrid orbitals have bond angles $120^\circ, 90^\circ$.

13. (a) In BeF_3^- , Be is not sp^3 -hybridised it is sp^2 hybridised.

17. (c) In molecule OF_2 oxygen is sp^3 hybridised.

18. (a) In sp^3 hybrid orbitals s -character is $1/4$ means 25%.

19. (d) XeF_4 molecule has ' Xe ' sp^3d^2 hybridised and its shape is square planar.

20. (b) The bond angle is maximum for sp hybridisation because two sp hybridised orbitals lies at angle of 180° .

21. (c) $\text{C}_2\text{H}_4\text{Br}_2$ has all single bonds so $\text{C}-\text{H}$ bond distance is the largest.

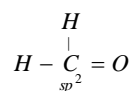
23. (a) In methane molecule C is sp^3 hybridised so its shape will be tetrahedral.

24. (c) In compound $\text{}^3\text{CH}_2 = \overset{2}{\text{C}} = \overset{1}{\text{CH}_2}$ the second carbon sp -hybridised.

25. (a) $\text{:}\ddot{\text{Cl}} \cdots \ddot{\text{Cl}}\text{:}$ is the correct electronic formula of Cl_2 molecule because each chlorine has 7 electrons in its valence shell.

26. (a) XeF_4 has sp^3d^2 hybridisation, its shape is square planar.

27. (b) In HCHO , carbon is sp^2 hybridized



28. (c) Because of the triple bond, the carbon-carbon bond distance in ethyne is shortest.

29. (b) The hybridisation of Ag in complex $[\text{Ag}(\text{NH}_3)_2]^+$ will be sp because it is a Linear complex.

30. (a) Structure of CO_2 is linear $\text{O} = \text{C} = \text{O}$ while that of H_2O is $\begin{array}{c} \text{O} \\ \diagup \quad \diagdown \\ \text{H} \quad \text{H} \end{array}$ i.e. bent structure so in CO_2 resultant dipole moment is zero while that of H_2O has some value.

31. (d) CO_2 is not sp^3 hybridised, it is sp hybridised.

32. (a) As compare to pure atomic orbitals, hybrid orbitals have low energy.
33. (d) $\overset{sp^2}{CH_2} = \overset{sp}{C} = \overset{sp^2}{CH} - \overset{sp^3}{CH_3}$ 1, 2-butadiene.
36. (b) CCl_4 is sp^3 hybridised so bond angle will be approximately 109° .
40. (b) Ethene has sp^2 hybridised carbon so bond angles are 120° .
44. (a) Acetate ion is $CH_3 - \overset{\text{O}}{\underset{\text{O}^-}{\text{C}}} \quad \text{i.e. one } C-O \text{ single bond and one } C=O \text{ double bond.}$
46. (c) Benzene has all carbons sp^2 hybridised and planar in shape.
47. (d) In methane C is sp^3 hybridized and bond angle is 109° .
56. (d)
$$\begin{array}{ccccc} & H & H & H & \\ & | & | & | & \\ H & - C & - C & - C & - H \\ & | & | & | & \\ & H & H & H & \end{array}$$

There are 10 shared pairs of electrons.
58. (a) The diborane molecule has two types of B-H bond :
(i) $B-H_t$ - It is a normal covalent bond.
(ii) $B-H_b$ - It is a three centred bond.
-
61. (b) PF_5 involves sp^3d hybridization and hence has trigonal bipyramidal structure.
62. (c) s -character in $sp = \frac{1}{2} \times 100 = 50\%$
 s -character in $sp^2 = \frac{1}{3} \times 100 = 33.3\%$
 s -character in $sp^3 = \frac{1}{4} \times 100 = 25\%$
Hence, maximum s -character is found in sp -hybridisation.
63. (b) The molecule of PCl_5 has sp^3d hybridisation, structure is trigonal bipyramidal.
64. (b) Merging (mixing) of dissimilar orbitals of different energies to form new orbitals is known as hybridisation and the new orbital formed are known as hybrid orbitals. They have similar energy.
65. (b) In SO_3 sulphur is sp^2 hybridized so its shape will be trigonal planar.
66. (a) These all are triangular with sp^2 hybridization.
67. (c) Bond length depends upon bond order and in benzene all $C-C$ bonds have same bond order.
68. (b) In C_2H_2 each carbon has sp -hybridization
$$\underset{sp}{H} - \underset{sp}{C} \equiv C - \underset{sp}{H}$$
70. (a) As p -character increases the bond angle decreases.
In sp - p -character $\frac{1}{2}$, bond angle - 180°
In sp^2 - p -character $\frac{2}{3}$, bond angle - 120°
In sp^3 - p -character $\frac{3}{4}$, bond angle - 109°
71. (a) sp^3 -hybridization called tetrahedral because it provides tetrahedral shape to the molecule.
72. (a) S-atom in SF_6 has sp^3d^2 hybridisation. So, the structure of SF_6 will be octahedral.
74. (b) Structure of H_2O_2 is non-planar. It has open book structure.
75. (d) Structure of N_2O is similar to CO_2 both have linear structure.
78. (a) $SnCl_2$ is V-shaped.
79. (d) In NH_4^+ nitrogen is sp^3 hybridised so 4 hydrogen situated at the corners of a tetrahedron.
81. (c) Increasing order of bond angle is $sp^3 < sp^2 < sp$.
 $109^\circ \quad 120^\circ \quad 180^\circ$
84. (a) NH_4^+ has sp^3 -hybridized nitrogen so its shape is tetrahedral.
86. (b) Bond angle increases with change in hybridisation in following order $sp^3 < sp^2 < sp$.
88. (c) In Diborane boron shows sp^3 -hybridization.
89. (a) Alkene does not show linear structure but it has planar structure due to sp^2 -hybridisation.
90. (c) Generally SF_4 consist of 10 electrons, 4 bonding electron pair and one lone pair of electron, hence it shows sp^3d hybridization.
92. (c) Atom/Ion Hybridisation
 NO_2^+ sp
 SF_4 sp^3d with one lone pair of electron
 PF_6^- sp^3d^2
93. (a) PF_3 consist of three bonding pair electrons and one lone pair of electron hence it shows sp^3 -hybridization.
94. (b) NO_2^+ shows sp -hybridization. So its shape is linear.
95. (c) Generally octahedral compound show sp^3d^2 -hybridization.
96. (a) In fifth group hydride bond angle decreases from top to bottom
 $NH_3 > PH_3 > AsH_3 > SbH_3 > BiH_3$.
97. (b) Generally NH_4^+ shows sp^3 hybridization.
98. (b) We know that single, double and triple bond lengths of carbon in carbon dioxide are 1.22 \AA , 1.15 \AA and 1.10 \AA respectively.
99. (b) It shows sp^2 -hybridization so it is planar.
101. (a) Bond angle of hydrides decreases down the group.

102. (b) Hybridization of N in NH_3 is sp^3 that of Pt in $[PtCl_4]^{2-}$ is dsp^2 that P in PCl_5 is sp^3d and that of B in BCl_3 is sp^2 .

103. (d) NH_4^+ and SO_4^{2-} both show sp^3 -hybridization and tetrahedral structure.

104. (a) It is shows sp^3d^3 -hybridization. Hence the bond angle is about 72° .

107. (a) s -character increases with increase in bond angle.

Hybridization	$s\%$	Angle
sp	50	180°
sp^2	33.3	120°
sp^3	25	109.28°
sp^3d^1	20	90° and 120°

108. (b) IF_7 molecule show sp^3d^3 -hybridization.

110. (a) PCl_3 contain three bonding and one lone pair electron. Hence shows sp^3 -hybridization.

111. (a) Ammonia and $(BF_4)^-$ shows sp^3 -hybridization.

112. (b) For square planar geometry hybridization is dsp^2 involving s, p_x, p_y and $d_{x^2-y^2}$ orbital.

113. (b) All carbon atoms of benzene consist of alternate single and double bond and show sp^2 hybridization.

116. (c) BCl_3 molecule show sp^2 -hybridization and planar structure.

117. (c) BCl_3 Boron trichloride molecule show sp^2 -hybridization and trigonal planar structure.

118. (b) SO_2 molecule shows sp^2 -hybridization and bent structure.

119. (c) Due to multiple bonding in N_2 molecule.

120. (a) % of s -character in

$$CH_4 = \frac{100}{4} = 25, \quad C_2H_4 = \frac{100}{3} = 33, \\ (sp^3) \quad (sp^2)$$

$$C_2H_2 = \frac{100}{2} = 50 \\ (sp)$$

121. (a) Acidic character increases when we come down a group, so HI is the strongest acid.

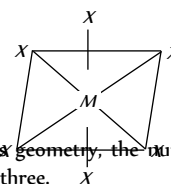
122. (c) SO_2 has sp^2 hybridization have the V shape structure ($<120^\circ$) due to 2 lone pair of electron over S atom. CO_2 and N_2O have the sp hybridization.

123. (a) In H_2CO_3 and BF_3 central atom are in sp^2 hybridization but in H_2CO_3 due to the ionic character of $O-H$ bond it will be polar (High electronegativity of oxygen).

124. (a) Due to sp^3 hybridization and presence of lone pair of electron on p atom PCl_3 are of pyramidal shape like that of NH_3 .

125. (b) There is sp hybridization in C_2H_2 so it has the linear structure.

126. (c) In octahedral molecule six hybrid orbitals directed towards the corner of a regular octahedron with a bond angle of 90° .

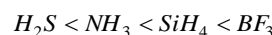


according to this geometry, the number of $X-M-X$ bond at 180° must be three.

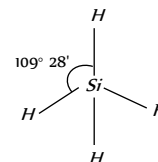
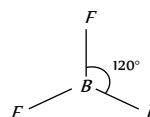
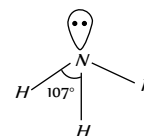
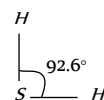
127. (d) sp^3d^2 hybrid orbital have octahedral shape

128. (c) In the formation of d^2sp^3 hybrid orbitals two $(n-1)d$ orbitals of e.g., set [i.e., $(n-1)d_{z^2}$ and $(n-1)d_{x^2-y^2}$ orbitals] one ns and three np [np_x, np_y and np_z] orbitals combine together and form six d^2sp^3 hybrid orbitals.

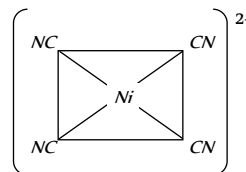
129. (c) The correct order of bond angle (Smallest first) is



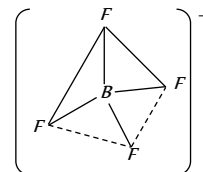
$$92.6^\circ < 107^\circ < 109^\circ 28' < 120^\circ$$



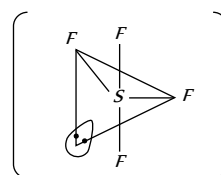
130. (a)



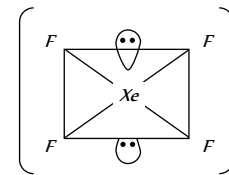
Square planar



Regular tetrahedral

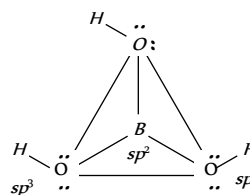


See saw shaped



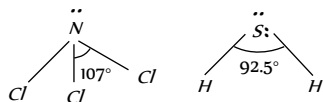
Square planar

131. (b)



132. (b) In the formation of BF_3 molecule, one s and $2p$ orbital hybridise. Therefore it is sp^2 hybridization.

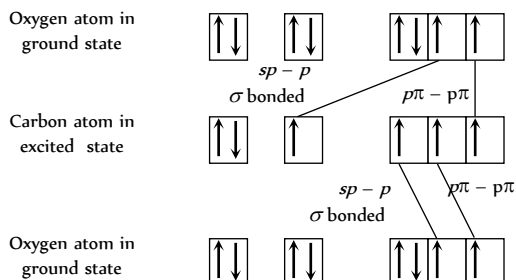
133. (e) In NCl_3 and H_2S the central atom of both (N and S) are in sp^3 hybridization state



while in BF_3 and NCl_3 central atoms are in sp^2 and sp^3 hybridization respectively. In H_2S and $BeCl_2$ central atom are in sp^3 and sp^2 hybridization. In BF_3 , NCl_3 & H_2S central atom are in sp^2 , sp^3 & sp^3 hybridization and in the central atom are in sp^3 and sp hybridization.

134. (c) $C_{\text{ground state}} = 2s^2, 2p_x^1 p_y^1$; $C_{\text{excited state}} = 2s^1, 2p_x^1 p_y^1 p_z^1$
 $O_{\text{ground state}} = 2s^2, 2p_x^2 p_y^1 p_z^1$

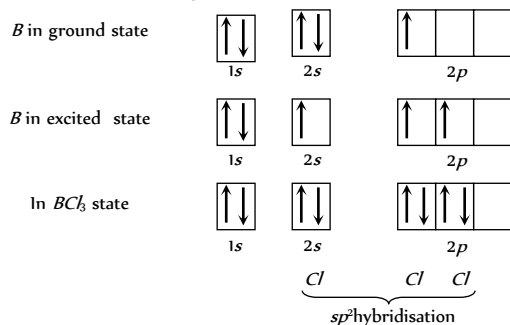
In the formation of CO_2 molecule, hybridization of orbitals of carbon occur only to a limited extent involving only one s and one p orbitals there is thus sp hybridisation of valence shell orbitals of the carbon atom resulting in the formation of two sp hybrid orbitals.



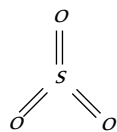
135. (d) In NH_3 , N undergoes sp^3 hybridization. Due to the presence of one lone pair, it is pyramidal in shape.

136. (b) NO_2 SF_4 PF_6^-
 sp sp^3d sp^3d^2

137. (b) The configuration of ${}_5B = 1s^2, 2s^2, 2p^1$



138. (d) In SO_3 molecule, S atom remains sp^2 hybrid, hence it has trigonal planar structure

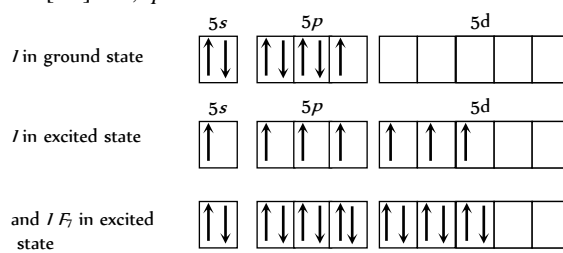


139. (a) In PCl_3 molecule, phosphorous is sp^3 - hybridised but due to presence of lone pair of electron, it has pyramidal structure



140. (a) The electronic configuration of

$I = [Xe] 5s^2, 5p^5$ hence



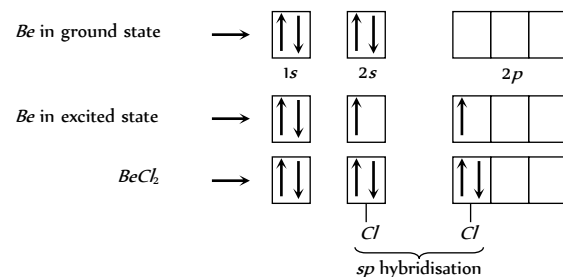
IF_7 shows sp^3d^2 hybridization. So, its structure is pentagonal bipyramidal.

141. (a) Compound containing highly electronegative element (F , O , N) attached to an electropositive element (H) show hydrogen bonding. Fluorine (F) is highly electronegative and has smaller size. So hydrogen fluoride shows the strongest hydrogen bonding in the liquid phase.

142. (b) In the ammonia molecule N atom is sp^3 - hybridized but due to the presence of one lone pair of e^- (i.e. due to greater $L_p - b_p$ repulsion) it has distorted tetrahedral (or pyramidal) geometry.

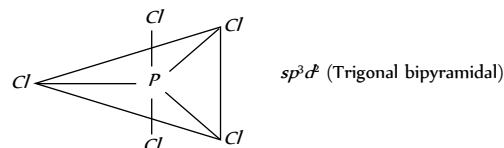


143. (a) ${}_4Be \rightarrow 1s^2, 2s^2, 2p^0$



144. (a) Except CO_3 other choice CO_2 , CS_2 and $BeCl_2$ have sp -hybridization and shows the linear structure while CO_3 have sp^3 hybridization and show the non linear structure because sp^3 generate tetrahedral structure.

145. (a) dsp^3 or sp^3d hybridization exhibit trigonal bipyramidal geometry e.g., PCl_5



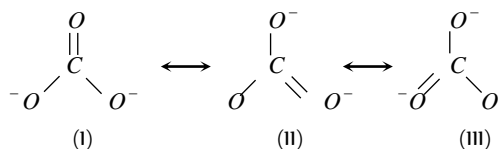
146. (b) Carbon has only two unpaired electrons by its configuration but hybridization is a concept by which we can explain its valency 4.

147. (c) Hybridization is due to overlapping of orbitals of same energy content.

148. (d) MX_3 show the sp^2 hybridization in which $3sp^2$ hybridized orbital of M bonded by $3X$ from σ bond and having the zero dipole moment.
149. (bcd) $SnCl_2$ has V-shaped geometry.
150. (a) NF_3 is predominantly covalent in nature and has pyramidal structure (the central atom is sp^3 hybridised) with a lone pair of electrons in the fourth orbital.
151. (ac) $PCl_3, NH_3 \rightarrow$ Pyramidal.
 $CH_4, CCl_4 \rightarrow$ Tetrahedral.
152. (a) dsp^3 or sp^3d : one s^+ three p^+ one $d(d_{z^2})$.

Resonance

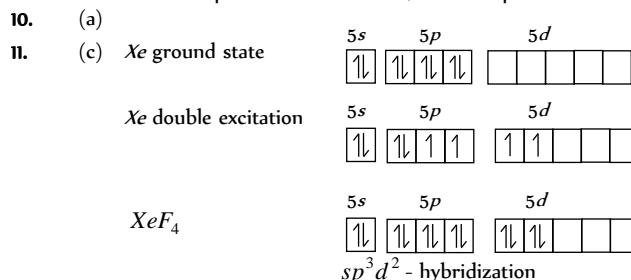
1. (d) Choice (a), (b), (c) are the resonance structures of CO_2 .
2. (b) In NH_3 nitrogen has one lone pair of electron.
5. (b) In CN^- ion formal negative charge is on nitrogen atom due to lone pair of electrons.
7. (a) $CH_3 - \overset{\cdot\cdot}{\underset{|}{C}} = CH_2$ has 9σ , 1π and 2 lone pairs.
8. (c) In resonance structure there should be the same number of electron pairs.
9. (b) There are three resonance structure of CO_3^{2-} ion.
11. (abcd) It has all the characteristics.



VSEPR Theory

2. (a) The bond angle in PH_3 would be expected to be close to 90° . (The bond angle $H-P-H$ in PH_3 is 93°)
3. (b) In BF_3 molecule Boron is sp^2 hybridised so its all atoms are co-planar.
4. (c) Due to $lp-lp$ repulsions, bond angle in H_2O is lower (104.5°) than that in NH_3 (107°) and CH_4 ($109^\circ 28'$). BeF_2 on the other hand, has sp -hybridization and hence has a bond angle of 180° .
5. (c) Compound is carbontetrachloride because CCl_4 has sp^3 - hybridization 4 orbitals giving regular tetrahedron geometry. In others the geometry is little distorted inspite of sp^3 hybridization due to different atoms on the vertices of tetrahedron.
6. (b) SO_4^{2-} ion is tetrahedral since hybridization of S is sp^3 .
7. (b) NH_3 molecule has one lone pair of electrons on the central atom i.e. Nitrogen.
8. (c) C_2H_2 has linear structure because carbons are sp -hybridised and lies at 180° .

9. (b) XeF_6 is distorted Octahedral. It has sp^3d^3 hybridisation with lone pair of electron on Xe , so its shape is distorted.

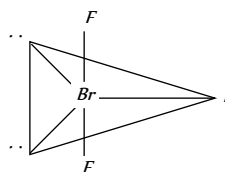


12. (a) CO_2 has bond angle 180° .
13. (a) As the s -character of hybridized orbitals decreases the bond angle also decreases
 In sp^3 hybridisation: s -character $1/4$, bond angle 109°
 In sp^2 hybridisation: s -character $1/3$, bond angle 120°
 In sp hybridisation: s -character $1/2$, bond angle 180°
14. (a) XeF_2 molecule is Linear because Xe is sp hybridised.
15. (c) SO_4^{2-} has 42 electrons; CO_3^{2-} has 32 electrons; NO_3^- has 32 electrons.
16. (c) Molecular oxygen contains unpaired electron so it is paramagnetic (according to MOT).
17. (b) Structure of H_2O is a bent structure due to repulsion of lone pair of oxygen.
18. (d) Bond angle between two hybrid orbitals is 105° it means orbitals are sp^3 hybridised but to lone pair repulsion bond angle get changed from 109° to 105° . So its % of s -character is between 22-23%.
22. (d) Number of electrons in ClO_2^-
 $= 7 + 6 + 6 + 1 = 20$
 Number of electrons in $ClF_2^+ = 7 + 7 + 7 - 1 = 20$.
23. (b) Central atom having four electron pairs will be of tetrahedral shape.

24. (d)
-
26. (c) It shows sp^2 -hybridization and show trigonal planar structure.
28. (b) H_2S show bond angle nearly 90° .
31. (a) Bond angle of hydrides is decreases top to bottom in the group.
 $NH_3 > PH_3 > AsH_3 > SbH_3$
32. (c)
-
- Three bond pair and one lone pair of electron.
33. (c) Unpaired electrons are present in KO_2 while others have paired electron
 $NO_2^+ = 22$ electrons ; $BaO_2 = 72$ electrons
 $AlO_2 = 30$ electrons ; $KO_2 = 35$ electrons
34. (a) Bond angle decreases from H_2O to H_2Te .

35. (c) BF_3 does not contain lone pair of electron.

36. (b)



Bent T-shaped geometry in which both lone pairs occupy the equatorial position of the trigonal bipyramidal here

$$(l_p - l_p) \text{ repulsion} = 0$$

$$(l_p - b_p) \text{ repulsion} = 4 \text{ and}$$

$$(b_p - b_p) \text{ repulsion} = 2$$

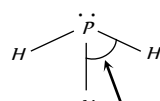
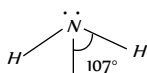
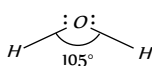
37. (b) The overall value of the dipole moment of a polar molecule depends on its geometry and shape *i.e.*, vectorial addition of dipole moment of the constituent bonds water has angular structure with bond angle 105° as it has dipole moment. However BeF_2 is a linear molecule since dipole moment summation of all the bonds present in the molecule cancel each other.



38. (d) BCl_3 , BBr_3 and BF_3 , all of these have same structure *i.e.* trigonal planar (sp^2 hybridization) Hence bond angle is same for all of them (*i.e.*, equal to 120°)

39. (d) We know that molecule of (NH_3) has maximum repulsion due to lone pair of electron. Its shape is pyramidal and is sp^3 hybridization.

40. (b)



As the electronegativity of central atom decreases bond angle is decreases

$\therefore NH_3$ has largest bond angle.

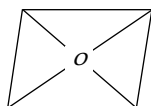
41. (c) In NH_3 , sp^3 -hybridization is present but bond angle is $106^\circ 45'$ because Nitrogen has lone pair of electron according to VSEPR theory due to $bp-lp$ repulsion bond angle decreases from $109^\circ 45'$ to $106^\circ 45'$.

42. (a) Bond strength decreases as the size of the halogen increases from F to I .

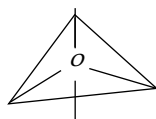
43. (b) NH_3 has pyramidal structure, yet nitrogen is sp^3 hybridised. This is due to the presence of lone pair of electron.

44. (c) SiF_4 has symmetrical tetrahedral shape which is due to sp^3 hybridization of the central sulphur atom in its excited state configuration. SF_4 has distorted tetrahedral or See-Saw geometry which arise due to sp^3d hybridization of central sulphur atom and due to the presence of lone pair of electron in one of the equatorial hybrid orbital.

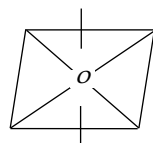
45. (d)



dsp^2 hybridization
(Four 90° angles between bond pair and bond pair)



sp^3d hybridization
(Six 90° angle between bond pair and bond pair)



sp^3d^2 hybridization
(Twelve 90° angle between bond pair and bond pair)

Molecular orbital theory

2. (c) $B.O. = \frac{\text{No. of bonding } e^- - \text{No. of antibonding } e^-}{2}$

$$= \frac{8-3}{2} = \frac{5}{2} = 2.5$$

3. (b) One bonding M.O. and one anti-bonding M.O.

4. (b) O_2^{2-} is least stable.

5. (c) B.O. of O_2 is 2, B.O. of O_2^- is 1.5, B.O. of O_2^{+1} is 2.5 and of O_2^{2-} is 1.

6. (d) Hydride of boron does not exist in BH_3 form. It is stable as its dimer di borane (B_2H_6).

10. (c) $O_2^- (2 \times 8 + 1 = 17)$ has odd number of electrons and hence it is paramagnetic. All the remaining molecules/ions, *i.e.*,

$CN^- (6 + 7 + 1 = 14)$ diamagnetic

$NO (7 + 8 = 15)$ has odd number of electrons and hence it is paramagnetic.

11. (c) $B.O. = \frac{\text{No. of } N_b - \text{No. of } N_a}{2} = \frac{5}{2} = 2.5$

12. (b) Bond order of O_2^+ is highest so its bond length is smallest.

13. (c) Oxygen is paramagnetic due to the presence of two unpaired electron :

$$O_2 = \sigma(1s)^2 \sigma^*(1s)^2 \sigma(2s)^2 \sigma^*(2s)^2$$

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

17. (d) In CH_3CN bond order between C and N is 3 so its bond length is minimum.

18. (b)

	He_2^+	H_2	H_2^+	H_2^-
$\sigma(1s)$	$\uparrow\downarrow$	$\uparrow\downarrow$	\uparrow	$\uparrow\downarrow$
$\sigma^*(1s)$	\uparrow	—	—	\uparrow
B.O.	$\frac{1}{2}$	1	$\frac{1}{2}$	$\frac{1}{2}$
Magnetic nature	P	D	P	P

(P = Paramagnetic, D = Diamagnetic)

19. (c) Due to unpaired e^- ClO_2 is paramagnetic.

20. (c) The Bond order in N_2 molecule is 3, $N \equiv N$ Here,
 $N_b = 2 + 4 + 2 = 8$ and $N_a = 2$
 $\therefore B.O. = (8 - 2)/2 = 3$.

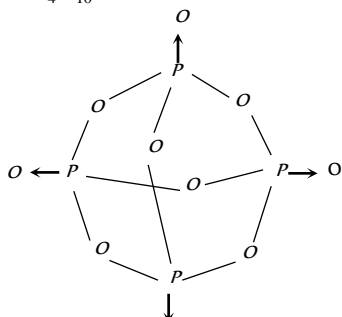
21. (d) H_2^+ has the bond order $\frac{1}{2}$, it has only one electron so it will be paramagnetic.

22. (c) When bond forms between two atom then their energy get lower than that of separate atoms because bond formation is an exothermic process.

23. (b) Valency of A is 3 while that of B is 2 so according to Criss Cross rule the formula of the compound between these two will be A_2B_3 .

24. (c) Due to resonance bond order of $C-C$ bonds in benzene is between 1 and 2.

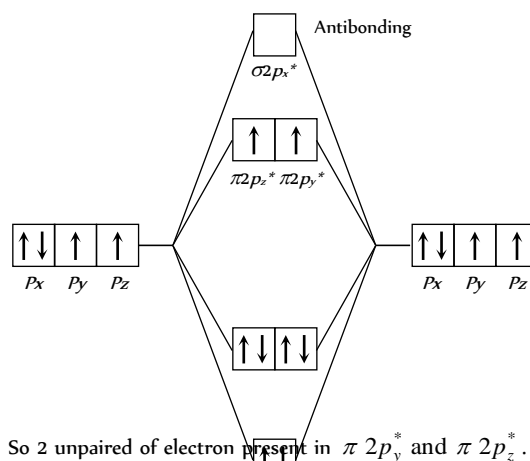
25. (a) Nitrogen does not have vacant 'd-orbitals' so it can't have +5 oxidation state i.e. the reason PCl_5 exists but NCl_5 does not.
26. (d) Molecules having unpaired electrons show paramagnetism.
27. (b) NO_2 has unpaired electrons so it would be paramagnetic.
30. (c) Helium molecule does not exist as bond order of $He_2 = 0$.
31. (c) Structure of P_4O_{10} is



Each phosphorus is attached to 4 oxygen atoms.

33. (c) B.O. of carbon = $\frac{N_b - N_a}{2} = \frac{8 - 4}{2} = 2$.
34. (a) B.O. = $\frac{N_b - N_a}{2} = \frac{10 - 4}{2} = 3$.
37. (b) B.O. = $\frac{N_b - N_a}{2} = \frac{8 - 3}{2} = \frac{5}{2} = 2.5$.
38. (a) Electronic configuration of O_2 is
 $O_2 = \sigma(1s)^2 \sigma^*(1s)^2 \sigma(2s)^2 \sigma^*(2s)^2 \sigma(2p_x)^2 \pi(2p_y)^2 \pi(2p_z)^2 \pi^*(2p_y)^1 \pi^*(2p_z)^1$
 The molecule has two unpaired electrons. So, it is paramagnetic.
40. (c) $\pi^* 2p_y$ has two nodal planes.
42. (a) Element with atomic number 26 is Fe. It is a ferromagnetic.
43. (b) Correct Sequence of bond order is
 $O_2^+ > O_2 > O_2^{2-}$
 B.O. = 2.5 2 1.5
44. (a) Due to small bond length.
45. (a) S^{-2} has all paired electrons so it is diamagnetic.
46. (c) NO has 15 electrons.
47. (b) In the conversion of O_2 into O_2^- bond order decreases.
49. (c) O_2^{2-} does not have any unpaired electron so it is diamagnetic.
50. (a) O_2^{2-} consists of four antibonding electron pairs [1s and 2s have two antibonding and $2p_x 2p_y$ have two antibonding electron pairs].
51. (c) The electron's distribution in molecular orbitals is $1s^2, 2s^1$
 B.O. = $\frac{2 - 1}{2} = \frac{1}{2} = 0.5$.
52. (b) ClO_2^- has all paired electrons hence it does not show paramagnetism.
53. (a) B.O. = $\frac{1}{2}[N_b - N_a]$
 $N_2 = \frac{1}{2}[10 - 4] = \frac{6}{2} = 3$; $O_2^{2+} = \frac{1}{2}[10 - 4] = \frac{6}{2} = 3$.
54. (a) B.O. for $N_2^+ = \frac{1}{2}[N_b - N_a] = \frac{1}{2}[9 - 4] = \frac{5}{2} = 2.5$.

55. (a) H_2O_2 contains bond angle between two $O-H$ planes about 90° .
56. (c) Nitrogen molecule has highest bond energy due to presence of triple bond.
57. (c) $Cu^{2+} = [Ar_{18}] 3d^9 4s^0$ it has one unpaired electron so it is paramagnetic.
59. (a) $CN^- = 14$ electrons; $CO = 14$ electrons
 B.O. = $\frac{1}{2}[10 - 4] = \frac{6}{2} = 3$.
60. (a) B.O. = $\frac{1}{2}[10 - 5] = \frac{5}{2} = 2.5$, paramagnetic
61. (a)
64. (c) The paramagnetic property in oxygen came through unpaired electron which can be explained by molecular orbital theory.



65. (a) Bond order = $\frac{\text{Total number of bonds between atoms}}{\text{Total number of resonating structures}}$
 $= \frac{5}{4} = 1.25$
66. (c) We know that carbonate ion has following resonating structures

 Bond order = $\frac{\text{Total number of bonds between atoms}}{\text{Total number of resonating structures}}$
 $= \frac{1 + 1 + 2}{3} = \frac{4}{3} = 1.33$.
67. (a) $O_2^+(15e^-) = K : K^* (\sigma 2s)^2 (\sigma^* 2s)^2 (\sigma 2p_x)^2 (\pi 2p_y)^2 (\pi 2p_z)^2 (\pi^* 2p_y)^1 (\pi^* 2p_z)^0$
 Hence, bond order = $\frac{1}{2}(10 - 5) = 2.5$
 $N_2^+(13e^-) = KK^* (\sigma 2s)^2 (\sigma^* 2s)^2 (\sigma 2p_x)^2 (\pi 2p_y)^2 (\pi 2p_z)^1$
 Hence, bond order = $\frac{1}{2}(9 - 4) = 2.5$.
68. (a) Electronic configuration of O_2 is

$$O_2 = (\sigma 1s)^2 (\sigma^* 1s)^2 (\sigma 2s)^2 (\sigma^* 2s)^2 (\sigma 2s)^2 (\sigma 2p_z)^2$$

$$(\pi 2p_x^2 \equiv \pi 2p_y^2) (\pi^* 2p_x^1 \equiv \pi^* 2p_y^1)$$

$$\text{Hence bond order} = \frac{1}{2} [N_b - N_a] = \frac{1}{2} [10 - 6] = 2.$$

69. (c) Nitrogen form triple bond $N \equiv N$

In which 6 electron take part.

70. (a) As bond order increase bond length decrease the bond order of species are

$$= \frac{\text{number of bonding electron} - \text{Number of a.b. electron}}{2}$$

$$\text{For } O_2 = \frac{10 - 6}{2} = 2;$$

$$O_2^+ = \frac{10 - 5}{2} = 2.5$$

$$O_2^- = \frac{10 - 7}{2} = 1.5$$

So, bond order $O_2^+ > O_2 > O_2^-$ and bond length are $O_2^+ > O_2 > O_2^-$.

71. (b) $O_2 : \sigma 1s^2, \sigma^* 1s^2, \sigma 2s^2, \sigma^* 2s^2, \sigma 2p_x^2 \left\{ \begin{matrix} \pi 2p_y^2 \\ \pi 2p_z^2 \end{matrix} \right\} \left\{ \begin{matrix} \pi^* 2p_y^1 \\ \pi^* 2p_z^1 \end{matrix} \right\}$

$$\text{Bond order} = \frac{10 - 6}{2} = 2.0$$

(Two unpaired electrons in antibonding molecular orbital)

$$O_2^+ : \sigma 1s^2, \sigma^* 1s^2, \sigma 2s^2, \sigma^* 2s^2, \sigma 2p_x^2 \left\{ \begin{matrix} \pi 2p_y^2 \\ \pi 2p_z^2 \end{matrix} \right\} \left\{ \begin{matrix} \pi^* 2p_y^1 \\ \pi^* 2p_z^0 \end{matrix} \right\}$$

$$\text{Bond order} = \frac{10 - 5}{2} = 2.5$$

(One unpaired electron in antibonding molecular orbital so it is paramagnetic)

72. (b) Higher the bond order, shorter will be the bond length, thus NO^+ having the higher bond order that is 3 as compared to NO having bond order 2 so NO^+ has shorter bond length.

73. (d) Oxygen molecule (O_2) boron molecule (B_2) and N_2^+ ion, all of them have unpaired electron, hence they all are paramagnetic.

74. (c) Bond order of NO^+ , NO and NO^- are 3, 2.5 and 2 respectively, bond energy \propto bond order

75. (a) Paramagnetic property arise through unpaired electron. B_2 molecule have the unpaired electron so it show paramagnetism.

$$B_2 \rightarrow \sigma 1s^2 \sigma^* 1s^2, \sigma 2s^2 \sigma^* 2s^2, \pi 2p_x^1 = \pi 2p_y^1$$

(2 unpaired electron)

$$C_2 \rightarrow \sigma 1s^2 \sigma^* 1s^2, \sigma 2s^2 \sigma^* 2s^2, \pi 2p_x^2, \pi 2p_y^2$$

(No unpaired electron)

$$N_2 \rightarrow \sigma 1s^2 \sigma^* 1s^2, \sigma 2s^2 \sigma^* 2s^2, \sigma 2p_x^2, \pi 2p_y^2, \pi 2p_z^2$$

(No unpaired electron)

$$F_2 \rightarrow \sigma 1s^2, \sigma^* 1s^2, \sigma 2s^2, \sigma^* 2s^2, \sigma 2p_x^2, \pi 2p_y^2, \pi 2p_z^2,$$

(No unpaired electron)

$$\pi^* 2p_y^2, \pi^* 2p_z^2$$

So only B_2 exist unpaired electron and show the paramagnetism.

76. (b) $O_2 \rightarrow \sigma 1s^2, \sigma^* 1s^2, \sigma 2s^2, \sigma^* 2s^2, \pi 2p_x^2 \left\{ \begin{matrix} \pi 2p_y^2 \\ \pi 2p_z^2 \end{matrix} \right\} \left\{ \begin{matrix} \pi^* 2p_y^1 \\ \pi^* 2p_z^1 \end{matrix} \right\}$

So two unpaired electron found in O_2 at ground stage by which it shows paramagnetism.

77. (b) Due to greater electron affinity Cl_2 has the highest bond energy.

78. (a) Molecular orbital electronic configuration of these species are :

$$O_2^-(17e^-) = \sigma 1s^2 \sigma^* 1s^2, \sigma 2s^2 \sigma^* 2s^2, \sigma 2p_x^2, \pi 2p_y^2,$$

$$\pi 2p_z^2, \pi^* 2p_y^2, \pi^* 2p_z^1$$

$$O_2(16e^-) = \sigma 1s^2 \sigma^* 1s^2, \sigma 2s^2 \sigma^* 2s^2, \sigma 2p_x^2, \pi 2p_y^2,$$

$$\pi 2p_z^2, \pi^* 2p_y^1, \pi^* 2p_z^1$$

$$O_2^{2-}(18e^-) = \sigma 1s^2 \sigma^* 1s^2, \sigma 2s^2 \sigma^* 2s^2, \sigma 2p_x^2, \pi 2p_y^2,$$

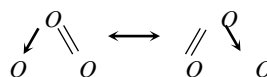
$$\pi 2p_z^2, \pi^* 2p_y^2, \pi^* 2p_z^2$$

Hence number of antibonding electrons are 7, 6, and 8 respectively.

79. (c) Species with unpaired electrons is paramagnetic O_2 has 2 unpaired electrons, O_2^- has one unpaired, O_2^{2-} has zero unpaired electrons, O_2^+ has one unpaired.

80. (a) O_2 has 2 unpaired electron while O_2^+ and O_2^- has one each unpaired electrons while O_2^{2+} does not have any unpaired electron.

81. (c) $H-O-O-H, O \leftarrow O = O, O = O$



Due to resonance in O_3 $O-O$ bond length will be in b/w $O=O$ and $O-O$.

82. (a) From valency bond theory, bond order in CO , i.e. $:\bar{C} \equiv \bar{O}:$ is 3, that of $O=C=O$ is 2 while that of CO_3^{2-} ion is 1.33. Since the bond length increases as the bond order decreases, i.e. $CO < CO_2 < CO_3^{2-}$.

83. (c) $N_2 : KK\sigma(2s)^2 \sigma^*(2s)^2 \pi(2p_x)^2 \pi(2p_y)^2 \sigma(2p_z)^2$ (diamagnetic)

$$C_2 : KK\sigma(2s)^2 \sigma^*(2s)^2 \pi(2p_x)^2 \pi(2p_y)^2$$

(diamagnetic)

$$N_2^+ : KK\sigma(2s)^2 \sigma^*(2s)^2 \pi(2p_x)^2 \pi(2p_y)^2 \sigma(2p_z)^2$$

(paramagnetic)

$$O_2^{2-} : KK\sigma(2s)^2 \sigma^*(2s)^2 \sigma(2p_z)^2 \pi(2p_x)^2 \pi(2p_y)^2$$

$$\pi^*(2p_x)^2 \pi^*(2p_y)^2$$

(diamagnetic)

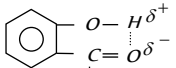
84. (d) $NH_3 = 107^\circ, PH_3 = 93^\circ, H_2O = 104.5^\circ$

$$H_2Se = 91^\circ, H_2S = 92.5^\circ$$

Hydrogen bonding

1. (d) Hydrogen bonding will be maximum in $F-H$ bond due to greater electronegativity difference.
2. (b) Ice has hydrogen bonding.
3. (b) $H-F$ has highest boiling point because it has hydrogen bonding.
6. (d) CO_2 is sp -hybridised
7. (b) sp -hybridization gives two orbitals at 180° with Linear structure.
8. (d) Hydrogen bonding increases the boiling point of compound.
9. (c) o -Nitrophenol has intramolecular hydrogen bonding but p -Nitrophenol has intermolecular hydrogen bonding so boiling point of p -Nitrophenol is more than o -Nitrophenol.
10. (c) The strongest hydrogen bond is in hydrogen fluoride because the power of hydrogen bond \propto electronegativity of atom and

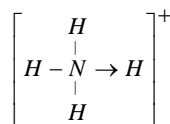
$$\text{electronegativity} \propto \frac{1}{\text{atomic size}}$$

So fluorine has maximum electronegativity and minimum atomic size.
11. (d) H_2O can form hydrogen bonds rest CH_4 and $CHCl_3$ are organic compound having no oxygen while $NaCl$ has itself intraionic attraction in the molecule.
12. (b) PH_3 has the lowest boiling point because it does not form Hydrogen bond.
14. (b) Hydrogen bonding increases heat of vaporisation.
15. (d) Only NH_3 forms H-bonds.
22. (a) Water molecule has hydrogen bonding so molecules get dissociated so it is liquid.
23. (d) In case of water, five water molecules are attached together through four hydrogen bonding.
25. (c) Hydrogen bond is strongest in hydrogen fluoride.
28. (c) Boiling point of H_2O is more than that of H_2S because H_2O forms hydrogen bonding while H_2S does not.
30. (c)  Interamolecular H -bonding.
31. (a) Hydrogen bond is formed when hydrogen is attached with the atom which is highly electronegative and having small radius.
34. (a) Water is dense than ice because of hydrogen bonding interaction and structure of ice.
35. (a) Ethanol have hydrogen bonding so its boiling point is higher than its isomer dimethyl ether.
36. (a) A compound having maximum electronegative element will form strong Hydrogen bond.
37. (a) Due to electronegativity difference of N_2 and H_2 , NH_3 form hydrogen bond.
38. (b) Intermolecular hydrogen bonding compound contain more b.p. compare to intramolecular hydrogen bonding compound.
39. (d) Water molecule contain hydrogen bonding.
40. (c) It contain intermolecular hydrogen bonding.
41. (b) Ethyl alcohol has a intermolecular hydrogen bond.
43. (b) HCl contain weak covalent bond.
45. (c) Due to intermolecular hydrogen bonding water molecules come close to each other and exist in liquid state.
46. (b) Due to greater resonance stabilization.

47. (d) C_2H_5OH will dissolve in water because it forms hydrogen bond with water molecule.
48. (b) In ice cube all molecules are held by inter molecular hydrogen bond.
49. (d) Hydrogen bonding is developed due to inter atomic attraction so it is the weakest.

Types of bonding and Forces in solid

1. (b) In electrovalent crystal has cation and anion are attached by electrostatic forces.
2. (d) Mercury has very weak interatomic forces so it remains in liquid state.
3. (c) The melting and boiling points of argon is low hence, in solid argon atoms are held together by weak Vander Waal's forces.
4. (c) NaF is the strongest ionic crystal so its melting point would be highest.
9. (b) Diamond is the hardest substance it's melting point would be highest.
10. (c) Bond is formed by attractive and repulsive forces of both the atoms.
12. (a) Generally zero group elements are linked by the Vander Waal's force. Hence these show weakest intermolecular forces.
13. (d) Glycerol has a three OH group hence it is viscous in nature.
14. (c) Vander waal's forces is the weakest force of attraction.
16. (b) NH_4^+ contain all three types of bond in its structure



17. (d) In $NaOH$ covalent bond is present in $O-H$ bond while ionic bond is formed between OH^- and Na^+ .
18. (a) Bond formation is an exothermic reaction so there is decrease in energy of product.
22. (d) Blue vitriol is $CuSO_4 \cdot 5H_2O$ and it has all types of bonds.

23. (a) $\left[\begin{array}{c} H \\ | \\ H - N \rightarrow H \\ | \\ H \end{array} \right]^+ Cl^-$
 Ionic bond = 1, Covalent bond = 3
 Co-ordinate bond = 1.

Critical Thinking Questions

1. (d) We know that ionic characters

$$= 16 [E_A - E_B] + 3.5 \times [E_A - E_B]^2$$
 or ionic characters = 72.24%
3. (c) Configuration of O_2 molecule is

$$[\sigma(1s)^2 \sigma^*(1s)^2 \sigma(2s)^2 \sigma^*(2s)^2 \pi(2p_x)^2 \pi(2p_y)^2 \sigma(2p_z)^2 \pi^*(2p_x)^1 \pi^*(2p_y)^1]$$
 No. of pair are 7 so total no. of paired electrons are 14.
6. (a) $\begin{array}{c} \cdot\cdot \\ H - \overset{\cdot\cdot}{O} : + H^+ \rightarrow H - \overset{\cdot\cdot}{O} \rightarrow H \\ | \qquad \qquad | \\ H \qquad \qquad H \end{array}$
7. (b) The correct order of increasing dipole moment is

p-dichlorobenzene < Toluene < *m*-dichlorobenzene < *o*-dichlorobenzene.

8. (a) The dipole moment of $CH_4 = 0D$, $NF_3 = 0.2D$, $NH_3 = 1.47D$ and $H_2O = 1.85D$. Therefore the correct order of the dipole moment is $CH_4 < NF_3 < NH_3 < H_2O$.

10. (d) Ammonia molecule is more basic than nitrogen trifluoride and Boron trifluoride because ammonia molecule easily gives lone pair of electron.

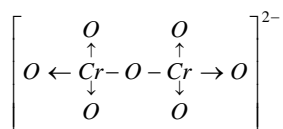
11. (a) Chlorine atom in ClO_2^- is sp^3 hybridised but its shape is angular.

12. (c) $[NF_3]$ and $[H_3O^+]$ are pyramidal while $[NO_3^-]$ and $[BF_3]$ are planar. Hence answer (c) is correct.

13. (d) $CH_2 = \underset{\substack{sp^2 \\ \text{hybridised}}}{CH} - \underset{\substack{sp^3 \\ \text{hybridised}}}{CH_2} - C \equiv CH$

14. (d) B.O. in CO i.e., $\overset{+}{C} \equiv \overset{-}{O}$ is 3, that of $O = C = O$ is 2 while that of CO_3^{2-} ion is 1.33. Since the bond length increases as the bond order decreases i.e. $CO < CO_2 < CO_3^{2-}$. Thus option (d) is correct.

15. (b) Dichromate dianion has following structure



6, $Cr-O$ bonds are equivalent.

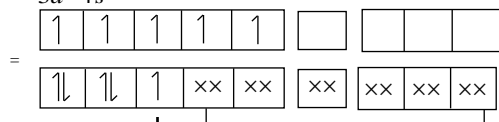
17. (b) ClF_3 is a $[AB_3]$ type of molecule because it consists of three bonding pair and two lone pair of electrons hence this compound shows sp^3d hybridization.

20. (a) BeF_3^- does not show sp^3 -hybridization because this compound is not formed.

21. (a) $K_3[Fe(CN)_6]$

$$Fe_{26} = 4s^2 3d^6$$

$$Fe^{3+} = 3d^5 4s^0$$



Unpaired electron

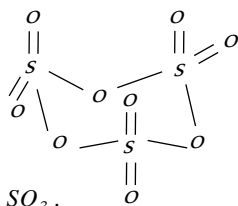
d^2sp^3 -hybridization

22. (d) N_2^+ has one unpaired electron so it would be paramagnetic.

23. (a) Each of the species has 14 electron so isoelectronic and shows bond order 3.

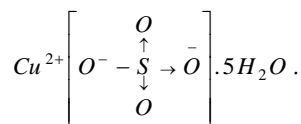
$$B.O. = \frac{1}{2}[N_b - N_a] = \frac{1}{2}[10 - 4] = \frac{6}{2} = 3.$$

24. (d)



Trimer of SO_3 .

27. (c) $CuSO_4 \cdot 5H_2O$ has electrovalent, covalent and coordinate bonds.

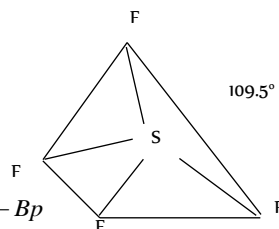


Assertion & Reason

1. (a) Solubility in water depends on hydration energy and lattice energy.

2. (a) Polarity in covalent bond developed due to shifting of electrons towards one of the bonded atoms.

5. (c) SiF_4 have sp^3 hybridization & shape of regular tetrahedral where the bond angle of $F-S-F$ are found 109.5° which is greater than 90° but less than 180° .



Repulsion sequence are $Lp-Lp > Lp-Bp > Bp-Bp$ so assertion are true but the reason are false.

9. (c) N_2 molecule is diamagnetic. The diamagnetic character is due to the presence of paired electron N_2 molecule does not contain any unpaired electron. Thus, assertion is correct but the reason is false.

10. (a) It is correct that during formation of ice from water there are vacant spaces between hydrogen bonded molecules of ice. Ice has a cage like structure. Due to this reason ice is less dense than liquid water. hence both assertion & reason are true & reason are the correct explanation of assertion.

11. (b) Water is liquid while H_2S is gas because oxygen is of small size & more electronegative in comparison to sulphur. Hence water molecules exist as associated molecules to form liquid state due to hydrogen bonding H_2S does not have hydrogen bonding & can't associated hence it is gas.

12. (d) Iodine is more soluble in CCl_4 than in H_2O because iodine is non polar & thus it dissolve in CCl_4 because like dissolves like.

13. (a) *o* & *p*-nitrophenols can be separated by steam distillation because *o*-nitrophenol is steam volatile. Here, both assertion & reason are correct & reason is correct explanation of assertion.

14. (e) Fluorine is highly reactive $F-F$ bond has low bond dissociation energy. Here assertion is false but reason is true.

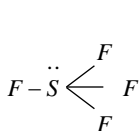
15. (c) It is true that sigma (σ) bond is stronger than pi (π) bond but the reason that there is free rotation of atoms is false.

16. (c) Energy is released in the formation of the crystal lattice. It is qualitative measure of the stability of an ionic compound so assertion is true & reason are false.

17. (c) *Li*, *Na* & *K* are alkali metals & not alkaline earth metal so, size of alkali metal increases So. Assertion is true & reason are false.

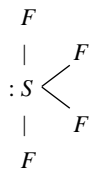
18. (b) Hess's law states that the enthalpy of a reaction is the same, whether it takes place in a single step or in more than one step. In born haber cycle the formation of an cycle ionic compound may occur either by direct combination of the element or by a stepwise process involving vaporization of elements, conversion of the gaseous atoms into ions & the combination of the gaseous ions to form the ionic solid.

19. (a) With increase in bond order, bond length decreases & hence bond energy increases so both assertion & reason are true & reason are the correct explanation of assertion.
20. (c) Electron affinity is experimentally measurable while electronegativity is a relative number so assertion is true but reason are false.
21. (b) Assertion & reason both are correct but reason is not the correct explanation of assertion sulphur has five electrons pairs whose arrangement should be trigonal bipyramidal according to VSEPR theory. Two structure are possible



(a)

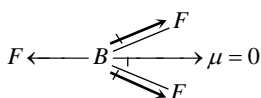
Lone pair in the axial position (three l.p - b.p repulsion at 90°)



(b)

Lone pair in the equatorial position (two L.p - b.p repulsion)

22. (e) BF_3 has zero dipole moment because of its structure.



H_2S has two lone pairs on sulphur atom & hence. It has irregular shape.

Thus it possess dipole moment. So assertion is false but reason are true.

23. (d) Both assertion & reason are false because pairs of electron will have different spins. Electrons are equally shared between them.
24. (d) In B_2 , total number of electrons = 10
 $B_2 \rightarrow \sigma(1s) \cdot \sigma^*(1s) \sigma(2s) \cdot \sigma^*(2s) \sigma(2p) \pi(2p)$
 Presence of unpaired electron shows the paramagnetic nature.
 The highest occupied molecular orbital is of π -type.
25. (a) Both assertion & reason are true & reason is the correct explanation of the assertion because. At any given instant, at room temperature each water molecules forms hydrogen bonds with other water molecules. The H_2O molecules are in continuous motion. So hydrogen bonds are constantly & rapidly broken & formed. In ice H_2O molecules are however fixed in the space lattice.
26. (a) Both assertion & reason are true & reason is the correct explanation of assertion, because helium molecule is formed by linking two helium atoms. both have $1s$ orbitals. These will combine to form two molecular orbitals $\sigma(1s)$ & $\sigma^*(1s)$ four available electrons are accommodated as $\sigma(1s)^2$ & $\sigma^*(1s)^2$.