MCQ 50 marks

1. **D.** 9 : 9
Explanation: In tetracyanoethylene $(NC)_2C = C(CN)_2$,
σ bonds = 1 (C = C) + 4 (C − C) + 4 (C ≡ N) = 9
π bonds = 1 + 4 × 2 = 9
Therefore, σ : π = 9 : 9

2. **B.** $sp^3 - sp$
Explanation: The carbon of the CH_3 group is sp^3 hybridized and the triply bonded carbon is sp hybridized.
Therefore, the C − C σ bond is formed by head-on overlap of $sp^3 - sp$ orbitals.

3. **C.** 6
Explanation: In borazine $B_3N_3H_6$, each N atom donates one lone pair (2 electrons) from its p-orbital to the ring π-system, and each B donates 0.
So, total π-electrons = 3 × 2 + 3 × 0 = 6

4. **A.** s **and** p_y
Explanation: When the x-axis is the internuclear axis, the p_y orbital is perpendicular to it and the s orbital is spherical.
The positive and negative overlaps of s and p_y cancel each other, so the net overlap is zero.

5. **A.** 1 **and** 2
Explanation: In pyrophosphoric acid $H_4P_2O_7$, the two P atoms are joined through one O atom.
So, bridging bonds (P − O − P) = 1
Also, each P carries one P = O, so double bonds = 2

6. **B.** sp^3d^2**, square pyramidal**
Explanation: Here, valence electrons of Xe = 8
Electrons used in 4 Xe − F and 1 Xe = O = 4 + 2 = 6
Remaining = 8 − 6 = 2 electrons = 1 lone pair
Steric number = 5 + 1 = 6
Therefore, hybridization is sp^3d^2 and the shape is square pyramidal

7. **D. In equatorial positions**
Explanation: In I_3^-, the steric number of the central I is 2 + 3 = 5, giving a trigonal bipyramidal arrangement.
To keep repulsion minimal, the 3 lone pairs occupy equatorial positions, so the shape is linear.

8. **A.** d_{z^2}
Explanation: PCl_5 undergoes sp^3d hybridization; the d_{z^2} orbital, directed along the axis of the trigonal bipyramid, takes part.

9. **B.** OF_2
Explanation: In OF_2, the steric number of O is 2 + 2 = 4, so it is sp^3 hybridized.
Because of the two lone pairs, the effective shape is bent or 'V'.

10. **C.** sp^3 **and** sp^3d^2
Explanation: Solid PCl_5 exists in the ionic form $[PCl_4]^+[PCl_6]^-$.
$[PCl_4]^+$: steric number = 4, hybridization sp^3
$[PCl_6]^-$: steric number = 6, hybridization sp^3d^2

11. **B. Presence of two lone pairs in equatorial positions**
Explanation: In ClF_3, the steric number of the central Cl is 3 + 2 = 5, giving a trigonal bipyramidal arrangement.
Repulsion is lowest when the two lone pairs occupy equatorial positions, so the three F atoms form a T-shape.

12. **B.** N_3^-
Explanation: In N_3^-, the steric number of the central N is 2 with no lone pair.
So the hybridization is sp and the shape is linear (180°).

13. **B. Distorted octahedral**
Explanation: In XeF_6, the steric number of Xe is 6 + 1 = 7.

Because of the one lone pair, the shape is a distorted octahedron rather than a regular one.

14. **C.** SF_4
Explanation: In SF_4, valence electrons of S = 6
Electrons used in 4 S − F bonds = 4
Remaining = 6 − 4 = 2 electrons = 1 lone pair
Therefore, bond pairs : lone pairs = 4 : 1

15. **C. All are sp^3 hybridized and tetrahedral**
Explanation: In all three species, the steric number of the central atom is 4 with no lone pair.
Therefore, each is sp^3 hybridized with a tetrahedral effective shape.

16. **B.** PH_3
Explanation: By Drago's rule, in hydrides of third-period and lower elements the energy gap between s and p orbitals is large, so hybridization hardly occurs.
So, in PH_3 the bonds are formed by almost pure p-orbitals (bond angle ≈ 93.5°).

17. **C.** $H_2O > H_2S > H_2Se > H_2Te$
Explanation: As the electronegativity of the central atom decreases, the bond pairs move away from the centre and bond pair–bond pair repulsion decreases.
So the bond angles follow H_2O (104.5°) > H_2S (92°) > H_2Se (91°) > H_2Te (90°)

18. **C.** SF_6
Explanation: In SF_6, S forms 6 S − F bonds.
Therefore, electrons in the valence shell = 6 × 2 = 12

19. **A. Reduced bond-pair repulsion**
Explanation: F is highly electronegative, so the N − F bond pairs shift towards F.
This reduces bond pair–bond pair repulsion near N, and the lone pair compresses the bond pairs more.
Therefore, the bond angle of NF_3 (102°) is smaller than that of NH_3 (107°).

20. **D.** NO_2^+
Explanation: In NO_2^+, the steric number of the central N is 2 with no lone pair, so it is sp hybridized and linear.
Therefore, the bond angle is 180°, the largest.

21. **D.** $P - Cl_{axial} > P - Cl_{equatorial}$
Explanation: In trigonal bipyramidal PCl_5, each axial bond makes 90° with 3 equatorial bond pairs, so it experiences more repulsion.
Therefore, $P - Cl_{axial} > P - Cl_{equatorial}$

22. **D.** NO_2
Explanation: In NO_2, total valence electrons = 5 + 2 × 6 = 17, an odd number.
So one unpaired electron is present and the molecule is paramagnetic.

23. **D.** sp^3
Explanation: In Al_2Cl_6, each Al is attached to four Cl atoms (2 terminal and 2 bridging).
Therefore, steric number = 4 and hybridization is sp^3

24. **C.** BCl_3
Explanation: In BCl_3, valence electrons of B = 3, and the 3 bonds give a total of 6 electrons around B.
Therefore, B cannot complete its octet (incomplete octet).

25. **B. 4 types**
Explanation: In the $CuSO_4 \cdot 5H_2O$ crystal,
ionic bond (between $[Cu(H_2O)_4]^{2+}$ and SO_4^{2-})
covalent bond (S − O, O − H)
coordinate covalent bond (Cu ← OH_2)
hydrogen bond (with the fifth water molecule)
Therefore, there are 4 types of bonds in total

26. **B.** 2 : 1
Explanation: H_3O^+ has 3 O − H bonds in total.
2 are ordinary covalent bonds from H_2O and 1 is a coordinate covalent bond with H^+
Therefore, covalent : coordinate = 2 : 1

27. **C. 3-centre 4-electron**
Explanation: In Al_2Cl_6, the bridging Cl is attached to both Al atoms, so 3 centres take part in the bond.
Here 4 electrons participate in the bridge (from the lone pairs of Cl).
Therefore, the bond is of 3-centre 4-electron nature

28. **D. Ionic, covalent and coordinate covalent**
Explanation: NH_4Cl is actually $[NH_4]^+Cl^-$.
Ionic bond between NH_4^+ and Cl^-

3 covalent and 1 coordinate covalent N − H bonds in NH_4^+

29. **D.** $SiCl_4$
Explanation: NaCl and $MgCl_2$ are ionic, $AlCl_3$ is partly covalent and $SiCl_4$ is a fully covalent molecular compound.
Molecular compounds have weak intermolecular forces, so $SiCl_4$ has the lowest melting point (≈ −70°C).

30. **A.** $BeCO_3$
Explanation: Be^{2+} is the smallest with the highest polarising power, so it distorts CO_3^{2-} the most.
Therefore, $BeCO_3$ decomposes at the lowest temperature.

31. **B.** Al^{3+}
Explanation: Ionic potential $\phi = \frac{z}{r}$ (where z = charge, r = ionic radius).
Al^{3+} has the highest charge (+3) and a small radius.
Therefore, Al^{3+} has the highest polarising power.

32. **A.** $MgSO_4 > CaSO_4 > SrSO_4 > BaSO_4$
Explanation: For group-2 sulfates, going down the group the lattice energy stays almost constant but the hydration energy decreases rapidly.
Therefore, the solubility order is $MgSO_4 > CaSO_4 > SrSO_4 > BaSO_4$

33. **B.** I^-
Explanation: The larger the anion, the more easily its electron cloud is distorted.
I^- is the largest, so it has the highest polarisability.

34. **A.** BF_3
Explanation: BF_3 is trigonal planar; the 3 B − F bond moments are equal and at 120° to each other.
So their vector resultant is zero and the net dipole moment is $\mu = 0$

35. **C.** $CH_3Cl > CH_2Cl_2 > CHCl_3 > CCl_4$
Explanation: Experimental values:
CH_3Cl (1.87 D), CH_2Cl_2 (1.60 D), $CHCl_3$ (1.04 D), CCl_4 (0)
As the number of Cl atoms increases, the vector cancellation of bond moments increases.
Therefore, the order is $CH_3Cl > CH_2Cl_2 > CHCl_3 > CCl_4$

36. **D. 1,4-dichlorobenzene**
Explanation: In 1,4-dichlorobenzene, the two C − Cl bond moments act in opposite directions (180°) with equal magnitude.
So the resultant is zero and $\mu = 0$

37. **D.** $\mu(NH_3) > \mu(NF_3)$
Explanation: In NH_3, the N − H bond moments and the lone-pair moment add in the same direction.
In NF_3, the N − F bond moments oppose the lone-pair moment and partly cancel it.
Therefore, $\mu(NH_3)$ (1.47 D) > $\mu(NF_3)$ (0.23 D)

38. **C. ortho-nitrophenol**
Explanation: In ortho-nitrophenol, the −OH and $-NO_2$ groups are adjacent, so an intramolecular hydrogen bond forms.
This reduces intermolecular attraction, lowers the boiling point and makes the compound easily vaporised.

39. **A.** $O_2^+ > O_2 > O_2^- > O_2^{2-}$
Explanation: Bond order = $\frac{N_b - N_a}{2}$
$O_2^+ = \frac{10-5}{2} = 2.5$, $O_2 = \frac{10-6}{2} = 2$
$O_2^- = \frac{10-7}{2} = 1.5$, $O_2^{2-} = \frac{10-8}{2} = 1$
Therefore, $O_2^+ > O_2 > O_2^- > O_2^{2-}$

40. **C. Breakdown of the ice-like open cage structure**
Explanation: On heating from 0°C to 4°C, the remaining hexagonal cage-like hydrogen-bonded clusters collapse, so molecules come closer and the density rises.
Above 4°C, thermal expansion dominates.
Therefore, the density is maximum at 4°C.

41. **B. Dimerisation through hydrogen bonding**
Explanation: In a non-polar solvent, two CH_3COOH molecules join through two intermolecular hydrogen bonds to form a dimer.
So the apparent molecular mass is double the normal value.

42. **C.** N_2

Explanation: Total electrons in N_2 = 14; bonding orbitals hold N_b = 10 and antibonding orbitals hold N_a = 4
Bond order = $\frac{10-4}{2}$ = 3
All electrons are paired, so the molecule is diamagnetic.

43. **D.** 3.0
Explanation: Total electrons in CO = 6 + 8 = 14 (isoelectronic with N_2).
N_b = 10, N_a = 4
Bond order = $\frac{10-4}{2}$ = 3.0

44. **D.** 1.33
Explanation: CO_3^{2-} has 1 C = O and 2 C − O bonds; total bond count = 2 + 1 + 1 = 4, shared equally among 3 bonds.
Therefore, bond order = $\frac{4}{3}$ = 1.33

45. **D. Weaker metallic bonding in larger atoms**
Explanation: Going down the group, the atomic radius increases while the number of valence electrons stays the same (1).
So the metallic bond weakens and the melting point decreases.

46. **B. Free electron sea model**
Explanation: In a metallic crystal, valence electrons move freely within the lattice of cations (the electron sea).
These free electrons reflect light to give lustre and carry heat and electricity.

47. **A. Only** NH_4Cl
Explanation: NH_4Cl contains an ionic bond between NH_4^+ and Cl^-, covalent N − H bonds and a coordinate $N \rightarrow H^+$ bond.
Therefore, all three bond types coexist only in NH_4Cl.

48. **C.** $18e^-$ **configuration of** Cu^+
Explanation: K^+ has a noble-gas configuration, whereas Cu^+ has d^{10}, i.e. an $18e^-$ (pseudo-noble-gas) configuration.
The d-electrons shield the nuclear charge poorly, so Cu^+ has a higher effective nuclear attraction and polarizing power.
Hence, by Fajans' rules, CuCl is more covalent than KCl.

49. **B. Increase in anion polarizability**
Explanation: From F^- to I^-, the anion size increases and its electron cloud is distorted more easily.
So the polarizability of the anion increases.
This increases the covalent character of the $Ag-X$ bond and the tendency for charge transfer.
Therefore, the colour intensity increases progressively.

50. **D.** HF_2^-
Explanation: The F^- ion binds to HF through hydrogen bonding.
$F^- + HF \rightarrow [F-H-F]^-$
Therefore, the anion is HF_2^- and the salt is KHF_2.