ZENITH EDUCATION

HPRCA Teacher (Chemistry) — B-Series MCQ Bank

Questions extracted from the source notes, kept complete (stem, four options, key, full explanation). No newly written questions.

Table 0.1: Navigation: questions per unit

Unit	Questions
Unit 1: Chemical Bonding and Molecular Structure	101
Unit 2: s- and p-Block Elements, Hydrides, Boranes and Noble Gases	58
Unit 3: Introductory Analytical Chemistry, Practical Analysis and Organic Reagents in Inor	33
Unit 4: Transition Elements, Lanthanides and Actinides	52
Unit 5: Coordination Chemistry and Organometallic Compounds	110
Unit 6: Atomic Spectroscopy and Electronic Spectra of Complexes	19
Unit 7: Basic Organic Concepts, Reactive Intermediates, Stereochemistry and Aromaticity	110
Unit 8: Alcohols, Phenols, Ethers, Carbonyl Compounds, Carboxylic Acids, Amines and Diazon	110
Unit 9: Nucleophilic and Radical Substitution, Aromatic Substitution, Named Reactions and	101
Unit 10: Pericyclic Reactions, Heterocycles, Polymers and Biomolecules	110
Unit 11: Solutions, Solids and Ionic Equilibria	110
Unit 12: Electrochemistry I and II	85
Unit 13: Chemical Thermodynamics I and II and Kinetics of Complex Reactions	110
Unit 14: Resonance, UV-Visible, Infrared and Mass Spectroscopy	110
Unit 15: Statistical Thermodynamics, Quantum Chemistry and Teaching of Chemistry	110
Total	1329

Unit 1: Chemical Bonding and Molecular Structure

Q1. Which hybridization corresponds to a linear geometry with bond angles of 180°?

(A) sp^2

(B) sp

(C) sp^3

(D) sp^3d

Answer: B. ution: sp hybridization involves 1 s + 1 p orbital, resulting in two regions of electron density (linear geometry, 180°).

Q2. Assertion (A): Resonance structures contribute equally to the actual molecule. Reason (R): Resonance stabilizes the molecule by delocalizing electrons.

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

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

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

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

Answer: B. A is false: Resonance structures do not contribute equally; their contribution depends on stability (e.g., structures with fewer charges contribute more). R is true: Resonance does stabilize molecules via electron delocalization. Parent Theory: Resonance theory (Robert Robinson, 1925). Exam Tip: "More stable = higher contribution" (e.g., benzene's Kekulé structures are equivalent but not equal in contribution).

Q3. Arrange the following compounds in order of increasing lattice energy (lowest to highest): 1. LiF 2. NaCl 3. MgO 4. Al_2O_3

(A) 1 < 2 < 4 < 3

(B) 2 < 1 < 3 < 4

(C) 1 < 3 < 2 < 4

(D) 4 < 3 < 2 < 1

Answer: B. Lattice energy (E) $\propto (q_1q_2)/r$, where q is charge and r is ionic radius. MgO (3+2 charge product, small r): Highest E. Al_2O_3 (6+3 charge product, but larger r): Second highest (due to higher charge but larger size). NaCl (1+1): Lower than MgO but higher than LiF (smaller r). LiF (1+1, smallest r): Highest among 1:1 salts but lower than MgO/Al_2O_3. Order: NaCl (2) < LiF (1) < MgO (3) < Al_2O_3 (4). Concept tested: Born-Landé equation and ionic radius effects. Exam tip: Higher charge → higher lattice energy, but radius dominates for same charge (e.g., LiF > NaCl).

Q4. Assertion (A): In molecular orbital theory, the bonding molecular orbital is always lower in energy than the antibonding orbital. Reason (R): The overlap of atomic orbitals leads to constructive and destructive interference, stabilizing or destabilizing the molecule. Which of the following is correct?

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

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

(C) A is false, but R is true.

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

Answer: D. Why A and R are true: Bonding MOs (σ, π) are lower in energy due to constructive interference; antibonding MOs (σ, π) are higher due to destructive interference. This is the core of MO theory. Why R explains A: The overlap mechanism directly causes energy differences between bonding/antibonding orbitals. Parent Theory: Molecular orbital theory; bonding/antibonding orbitals. Exam Tip: Remember the "σ < π < σ" energy ordering for homonuclear diatomics (e.g., O_2, N_2).

Q5. The lattice energy of NaCl estimated from Born-Landé equation is 766 kJ/mol. If the Madelung constant for NaCl is 1.748, the nearest neighbour distance is 2.82 Å, and the Born exponent n=9, then the calculated value (in kJ/mol) using the Born-Landé equation is closest to:

(A) 750

(B) 766

(C) 800

(D) 700

Answer: B. This is a statement verification: The Born-Landé equation: $U = -(N_A M z^+ z^- e^2)/(4\pi\varepsilon_0 r_0)(1 - (1)/(n))$. Plugging values yields ~766 kJ/mol. Option B is the given value, so correct. This question tests recall of the famous result for NaCl.

Q6. Which of the following is a necessary condition for a vibrational mode to be Raman active?

(A) The mode must change the dipole moment.

(B) The mode must change the polarizability of the molecule.

(C) The molecule must have a center of inversion.

(D) The mode must be totally symmetric.

Answer: B. Raman activity depends on the change in polarizability (α) during the vibration. IR activity depends on the change in the permanent dipole moment.

Q7. Why does Li_2CO_3 decompose on heating, unlike other Group 1 carbonates?

(A) Small size → high lattice energy

(B) Forms covalent bonds

(C) Low hydration energy

(D) High melting point

Answer: A. Small size → high lattice energy Li^+ is small → strong lattice energy → CO_2 escapes easily. Comparison: Na_2CO_3 requires higher temp (850°C) due to larger Na^+.

Q8. Which software is most appropriate for visualizing 3D molecular orbitals and electron density maps in an advanced Chemistry curriculum?

(A) Spreadsheet software (e.g., Excel)

(B) Gaussian or Chem3D

(C) Word processing software

(D) Presentation software (e.g., PowerPoint)

Answer: B. Gaussian and Chem3D are specialized computational chemistry tools designed for quantum mechanical calculations and 3D visualization. Spreadsheets and word processors lack the rendering capabilities for complex molecular orbitals. 5. Assertion (A): Virtual laboratories are superior to physical laboratories for teaching hazardous chemical reactions.

Q9. 29. The bond order in NO calculated from its MO diagram (assuming the order $\sigma_{1s}<\sigma_{1s}^*<\sigma_{2s}<\sigma_{2s}^*<\pi_{2p}=\sigma_{2p}<\pi_{2p}^*<\sigma_{2p}^*$) is:

(A) 2.5

(B) 2.0

(C) 3.0

(D) 1.5

Answer: A. NO is a heteronuclear diatomic with 15 electrons (N=7, O=8). The MO energy ordering for lighter molecules: σ_{2s},σ_{2s},π_(2p_x)=π_(2py),σ_(2pz),π_(2p_x)^,π_(2py)^,σ_(2pz)^. Filling 15 electrons: σ_{2s}^2,σ_{2s}^(2),π_{2p}^4,σ_(2pz)^2,π_{2p}^1. Bond order = (bonding electrons - antibonding)/2 = (10 - 5)/2 = 2.5. NO is paramagnetic with one unpaired electron in π^. So A is correct. Options B (NO+ has bond order 3), C (N2 has 3), D (O2- has 1.5).

Q10. What is the bond order of H_2?

(A) 0

(B) 1

(C) 2

(D) 3

Answer: B. (Key as given in source notes.)

Q11. (Assertion-Reason) Assertion (A): The molecule Be_2 does not exist. Reason (R): In Be_2, the bond order is zero as per molecular orbital theory.

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

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

(C) A is true, but R is false.

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

Answer: A. Be_2 has 8 electrons: configuration $(\sigma_{1s})^2(\sigma_{1s})^2(\sigma_{2s})^2(\sigma_{2s})^2$. Bond order = (4-4)/2 = 0. Hence Be_2 is unstable (not observed). Both A and R true; R correctly explains nonexistence.

Q12. According to Fajans' rules, the covalent character in the following compounds increases in the order:

(A) AgF < AgCl < AgBr < AgI

(B) AgI < AgBr < AgCl < AgF

(C) LiCl < NaCl < KCl < RbCl

(D) BeO > MgO > CaO > SrO

Answer: A. Fajans' rules: Covalent character increases with increasing size of anion and decreasing size of cation. For silver halides, anion size: F- (small) < Cl- < Br- < I- (large). So covalent character increases: AgF < AgCl < AgBr < AgI. Option A is correct. Option B reverses order. Option C: as cation size increases, polarizing power decreases, so covalent character decreases: LiCl > NaCl > KCl > RbCl. Option D: For oxides, as cation size increases, polarizing power decreases, covalent character decreases: BeO > MgO > CaO > SrO, so order is correct but not increasing. So only A is correct.

Q13. According to Fajan's rules, covalent character in an ionic bond increases with: 1. Small cationic size 2. Large anionic size 3. High charge on either ion 4. Presence of inert gas configuration in cation Select the correct combinations:

(A) 1, 2, 3

(B) 1, 2, 4

(C) 2, 3, 4

(D) 1, 3, 4

Answer: A. Fajan's rules: small cation, large anion, high charges favor polarization and covalent character. The electron configuration of the cation (inert gas vs pseudo-inert gas) also matters: cations with (n-1)$d^{10}ns^0$ (pseudo-inert gas) cause more polarization than those with inert gas configuration. So statement 4 is false (inert gas config reduces polarization). Hence A.

Q14. In a molecule, the bond length is inversely proportional to:

(A) Bond order

(B) Bond dissociation energy

(C) Atomic radius

(D) Electronegativity difference

Answer: A. Bond length decreases as bond order increases (more electron density between nuclei). Option A is correct. Bond dissociation energy is directly related to bond strength, not always inversely to length? Generally, stronger bonds (higher D.E.) are shorter, so bond length is inversely proportional to bond strength, not directly. But the question asks "inversely proportional to", and bond order is a direct factor. Better: Bond length is approximately inversely proportional to bond order for a given pair of atoms. So A is the best. Option B: BDE is roughly proportional, not inversely. C: atomic radius increases bond length. D: electronegativity difference affects bond polarity, not length in simple proportionality.

Q15. The resonance energy of benzene is:

(A) 28 kcal/mol

(B) 36 kcal/mol

(C) 48 kcal/mol

(D) 60 kcal/mol

Answer: B. 36 kcal/mol Resonance energy = 36 kcal/mol (exam standard). Heat of hydrogenation of benzene = 288 kJ/mol (vs. cyclohexene = 129 kJ/mol). Calculation: RE = (ΔH_hydrogenation of hypothetical alkene) – (ΔH_hydrogenation of benzene).

Q16. Which of the following hybridizations and corresponding molecular geometries are correctly matched?

(A) sp^3 hybridization → trigonal planar geometry

(B) sp^2 hybridization → tetrahedral geometry

(C) sp hybridization → linear geometry

(D) dsp^2 hybridization → trigonal bipyramidal geometry

Answer: C. sp hybridization (one s and one p orbital) produces linear geometry (e.g., $BeCl_2$). sp^3 is tetrahedral, sp^2 trigonal planar, and dsp^2 is square planar. Why A is wrong: sp^3 gives tetrahedral (e.g., CH_4), not trigonal planar. Why B is wrong: sp^2 gives trigonal planar (e.g., BF_3), not tetrahedral. Why D is wrong: dsp^2 hybridizes d, s, and p orbitals to form square planar (e.g., $PtCl_4^{2-}$), not trigonal bipyramidal. Parent Theory: Hybridization and VSEPR theory; molecular geometries. Exam Tip: Use the formula: (number of hybrid orbitals) = (number of regions of electron density). sp = 2 → linear; sp^2 = 3 → trigonal planar; sp^3 = 4 → tetrahedral.

Q17. Assertion (A): MgO has a higher melting point than NaCl. Reason (R): The product of ionic charges in MgO (2×2 = 4) is four times that in NaCl (1×1 = 1), leading to a much larger lattice energy.

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

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

(C) A is true, but R is false.

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

Answer: A. Both A and R are true, and R is the correct explanation.

Q18. The lattice energy of MgO is higher than that of NaF. Which factor best explains this observation?

(A) MgO has a larger ionic radius

(B) MgO has a greater charge on its ions

(C) MgO has a more covalent character

(D) MgO has a higher molar mass

Answer: B. Lattice energy $\propto (q_1\, q_2)$ / r, where q are ionic charges. Mg^{2+} and O^{2-} have higher charges than Na^+ and F^-. Parent theory: Kapustinskii equation and factors affecting lattice energy. Exam tip: Higher charge product → stronger electrostatic attraction → higher lattice energy.

Q19. The correct statement about bond lengths in the ozone (O_3) molecule is:

(A) Both O–O bonds are equal in length (128 pm) due to resonance.

(B) The central O–O bond is shorter than the terminal O–O bond.

(C) The O–O bonds are longer than that in O_2 molecule (121 pm).

(D) The bond order in O_3 is 2.

Answer: A. In ozone, resonance hybrids give two equivalent O–O bonds (bond length = 128 pm), intermediate between O–O single bond (~148 pm) and O=O double bond (121 pm). So A correct. B false (equal lengths

Q20. Considering the molecular orbital diagram of N_2, which of the following has the highest bond dissociation energy?

(A) N_2^+

(B) N_2

(C) N_2^{2-}

(D) N_2^-

Answer: B. N_2 has bond order 3 (10 bonding – 4 antibonding)/2 = 3. N_2^+: bond order = 2.5; N_2^-: bond order = 2.5; N_2^{2-}: bond order = 2. Bond dissociation energy $\propto$ bond order. N_2 with bond order 3 has the highest.

Q21. Column I (Bond)Column II (Characteristic)1. B–H(terminal)(i) Bond length 1.19 Å, stronger than the other B–H bond2. B–

H(bridge)(ii) Involves a three-centre two-electron (3c-2e) bond3. B–B interaction(iii) Bond order ~0.5 per B–B

(A) 1–(i), 2–(ii), 3–(iii)

(B) 1–(ii), 2–(i), 3–(iii)

(C) 1–(i), 2–(iii), 3–(ii)

(D) 1–(iii), 2–(ii), 3–(i)

Answer: A. B–H(terminal) bonds are conventional 2c-2e bonds, ~1.19 Å, stronger than the bridging B–H bonds (~1.33 Å). B–H(bridge) bonds are 3c-2e bonds (B–H–B). The B–B distance in diborane is ~1.77 Å, but there is no direct B–B bond; the interaction is through the bridging hydrogens with a formal bond order of about 0.5. Thus correct matching: 1–(i), 2–(ii), 3–(iii). 4. (Multi-statement) Which of the following statements about silicones is/are correct? (i) Silicones are linear or cyclic polymers of the general formula $(R_2SiO)_n$, where R is an alkyl or aryl group. (ii) The siloxane backbone (Si–O–Si) is highly flexible due to the large Si–O–Si bond angle (~140°).

Q22. Hydrolytic degradation of polyesters is generally faster than that of polyamides. Which factor primarily accounts for this?

(A) Higher crystallinity of polyamides

(B) Greater polarity of the ester group

(C) Amide bonds are more resonance-stabilised than ester bonds

(D) Polyamides have higher molecular weight

Answer: C. Amide bonds have significant resonance between N lone pair and C=O, making the carbonyl carbon less electrophilic and the bond more resistant to hydrolysis. Esters have less resonance stabilisation, thus more susceptible to nucleophilic attack by water (especially in acidic/basic conditions). Crystallinity & molecular weight affect rate but not the intrinsic chemical stability; polarity argument is not primary.

Q23. (Multi-Statement – VSEPR and Lone Pairs) Consider the following statements regarding VSEPR theory: (I) In ClF_3, the F–Cl–F bond angles are all 120°. (II) The lone pairs in SF_4 occupy equatorial positions in the trigonal bipyramidal arrangement. (III) In IF_7, the geometry is pentagonal bipyramidal. (IV) XeF_2 is linear because the three lone pairs occupy equatorial positions. Which are correct?

(A) I, II, III

(B) II, III, IV

(C) I, III, IV

(D) I, II, IV

Answer: B. (I) false – ClF_3 has T-shaped geometry; bond angles are ~87.5° and ~175°, not 120°. (II) true – SF_4 is see-saw, lone pair equatorial. (III) true – IF_7 is pentagonal bipyramidal (5+2). (IV) true – XeF_2 has 5 electron pairs (3 lone, 2 bond); lone pairs occupy equatorial trigonal bipyramidal positions, giving linear XeF_2. Hence II, III, IV correct.

Q24. In the MO theory of nitric oxide (NO), what is the ground state bond order and the number of unpaired electrons?

(A) Bond order = 2.5, 1 unpaired electron

(B) Bond order = 2, 1 unpaired electron

(C) Bond order = 2.5, 0 unpaired electrons

(D) Bond order = 3, 1 unpaired electron

Answer: A. NO has 11 valence electrons: NO^+ configuration: $(\sigma 2s)^2(\sigma 2s)^2(\sigma 2p_z)^2(\pi 2p)^4(\pi 2p)^1$. So bond order = (8-3)/2 = 2.5. One unpaired electron in π. Hence A.

Q25. In LCAO–MO theory, which of the following conditions is NOT required for effective combination of two atomic orbitals?

(A) The atomic orbitals must have similar energy.

(B) The atomic orbitals must have the same symmetry about the internuclear axis.

(C) The overlap integral must be non-zero.

(D) The atomic orbitals must come from the same principal quantum number.

Answer: D. The three conditions for LCAO are: energy similarity, proper symmetry (matching), and non-zero overlap. The principal quantum number need not be the same; e.g., 2s and 2p can combine if energy and symmetry allow. Hence D is not required.

Q26. Assertion (A): Nitrobenzene undergoes nitration to give meta-dinitrobenzene as the major product. Reason (R): The $–NO_2$ group is a meta director because it withdraws electron density by resonance.

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

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

(C) A is true, but R is false.

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

Answer: A. Both A and R are true, and R explains A (the meta position has the least depletion of electron density).

Q27. Arrange the following developments in Molecular Orbital Theory in correct chronological order: (I) Hückel's π-electron theory for conjugated hydrocarbons. (II) Mulliken's systematic application of LCAO-MO to diatomic molecules. (III) Lennard-Jones introduction of the correlation diagram for homonuclear diatomics. (IV) Hund's discovery of the Aufbau principle for molecular orbitals in diatomic molecules.

(A) (I) → (III) → (II) → (IV)

(B) (IV) → (II) → (III) → (I)

(C) (III) → (I) → (IV) → (II)

(D) (II) → (IV) → (III) → (I)

Answer: B. Hund (1925–1926) proposed the Aufbau principle and qualitative MO diagrams. Mulliken (1928–1932) developed LCAO-MO and notation. Lennard-Jones (1929) constructed correlation diagrams linking atoms to molecules. Hückel (1931) published the π-electron theory, which came later than Hund's work. Thus correct order: Hund → Mulliken → Lennard-Jones → Hückel; i.e., IV → II → III → I. 32. Multi-Statement Which of the following are correct statements about the character table of the C_{2v} point group? 1. It has four irreducible representations, all one-dimensional. 2. The characters of the identity operation are all +1.

Q28. For a diatomic molecule AB, the dipole moment is 1.2 D and the bond length is 1.0 Å. If the charge on the electron is 4.8×10^{-10} esu, the percentage ionic character is:

(A) 10%

(B) 20%

(C) 25%

(D) 50%

Answer: C. For 100% ionic character, dipole moment μ_(100\%) = e × d. e = 4.8×10^{-10} esu, d = 1.0×10^{-8} cm. So μ_(100\%) = 4.8×10^{-18} esu·cm = 4.8 D. Observed μ = 1.2 D. Percentage ionic character = (observed/calculated) × 100 = (1.2/4.8)×100 = 25%. Option C is correct.

Q29. In VBT (Valence Bond Theory), the hybridization of Co^{3+} in $[Co(NH_3)_6]^{3+}$ is:

(A) sp^3

(B) sp^2

(C) dsp^2

(D) d^2sp^3

Answer: D. Co^{3+}: d^6 → low-spin (strong field NH_3). Hybridization: d^2sp^3 (6 coordination sites, octahedral). A (sp^3): Tetrahedral, not octahedral. C (sp^2): Linear, not applicable. D (dsp^2): Square planar (e.g., Pt^{2+}). Key Theory: VBT hybridization in octahedral complexes. Exam Tip: d^2sp^3 is only for octahedral d^6 low-spin (e.g., $[Co(NH_3)_6]^{3+}$).

Q30. Which of the following theories explains the color of transition metal complexes?

(A) Molecular Orbital Theory (MOT)

(B) Crystal Field Theory (CFT)

(C) Hybridization Theory

(D) Valence Bond Theory (VBT)

Answer: B. VBT: Explains bonding but not color. CFT: Explains d-orbital splitting → absorption of light → color. MOT: Explains bonding but not color in simple terms. Hybridization: Explains geometry but not color. Concept tested: Spectrochemistry and transition metal complexes. Exam tip: CFT explains color via d-d transitions (e.g., $[Ti(H_2O)_6]^{3+}$ is purple).

Q31. (Match the Following – MO Diagrams) Match the species in List I with the correct ground-state electron configuration (molecular orbitals) in List II. List I | List II

|

P. N_2 | 1. $(\sigma_{1s})^2(\sigma_{1s})^2(\sigma_{2s})^2(\sigma_{2s})^2(\pi_{2px})^2(\pi_{2py})^2(\sigma_{2p})^2$ Q. O_2 | 2. $(\sigma_{1s})^2(\sigma_{1s})^2(\sigma_{2s})^2(\sigma_{2s})^2(\pi_{2px})^2(\pi_{2py})^2(\pi_{2px})^1(\pi_{2py})^1$

R. B_2 | 3. $(\sigma_{1s})^2(\sigma_{1s})^2(\sigma_{2s})^2(\sigma_{2s})^2(\pi_{2px})^1(\pi_{2py})^1$ S. Li_2 | 4. $(\sigma_{1s})^2(\sigma_{1s})^2(\sigma_{2s})^2$

(A) P-4, Q-2, R-3, S-1

(B) P-1, Q-2, R-3, S-4

(C) P-2, Q-1, R-4, S-3

(D) P-3, Q-1, R-2, S-4

Answer: B. N_2 ($14e^-$): BO=3, configuration 1. O_2 ($16e^-$): BO=2, two unpaired π electrons – configuration 2. B_2 ($10e^-$): BO=1, two unpaired π electrons – configuration 3. Li_2 ($6e^-$): BO=1, only σ_{2s} – configuration 4. Hence P-1, Q-2, R-3, S-4.

Q32. In molecular orbital theory, the bonding in O_2 is best described as:

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

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

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

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

Answer: C. O_2 has two unpaired electrons in π orbitals (paramagnetic), which requires the configuration in A. Option B incorrectly pairs all electrons. Option C misorders the σ and π orbitals. Option D also pairs all electrons, violating O_2's paramagnetism. Key Theory: Molecular orbital diagram (MO theory). Exam Tip: Use the aufbau principle and Hund's rule to fill orbitals correctly.

Q33. Assertion (A): The hybridization of the central atom in PCl_5 is sp^3d. Reason (R): PCl_5 has a trigonal bipyramidal geometry with five bonding pairs and no lone pairs.

(A) Both A and R are true but R is NOT the correct explanation of A

(B) A is true but R is false

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

(D) A is false but R is true

Answer: C. A is true: PCl_5 is sp^3d hybridized. R is true and explains A: Five bonding pairs → trigonal bipyramidal → sp^3d hybridization. Parent theory: VSEPR → hybridization mapping. Exam tip: Count regions of electron density to determine hybridization.

Q34. According to Fajans' rules, which statement is correct?

(A) Small cations always increase covalent character.

(B) Large anions always increase covalent character.

(C) Low electronegativity difference increases covalent character.

(D) High ionization energy increases covalent character.

Answer: C. Fajans' rules: 1. Small, highly charged cations polarize large anions → more covalent character. 2. Large anions are easily distorted → more covalent character. 3. Low electronegativity difference → more covalent character (e.g., $AlCl_3$ vs. NaCl). Option A: Incorrect (small cations do increase covalent character, but not "always"). Option B: Incorrect (large anions do increase covalent character, but not "always"). Option C: Correct (low electronegativity difference → more covalent character). Option D: Incorrect (ionization energy affects ionization, not covalent character). Key phrase: "Low electronegativity difference increases covalent character." Example: $AlCl_3$ (Al: 1.61, Cl: 3.16 → ΔEN = 1.55) is more covalent than NaCl (Na: 0.93, Cl: 3.16 → ΔEN = 2.23).

Q35. Which statement is true about the polarity of HF molecule according to Molecular Orbital Theory?

(A) HF is nonpolar because the σ bonding MO is equally shared.

(B) The MO calculation shows that the σ bonding MO has more contribution from the fluorine 2p orbital than from hydrogen 1s, resulting in a polar bond.

(C) The bond order of HF is 0.5 due to only one electron pair.

(D) HF has a net bond order of 0 because it uses only s orbitals.

Answer: B. HF has 8 valence electrons. The σ bonding MO is polarized toward F because F is more electronegative; its 2p orbital contributes more to the bonding MO. Hence the molecule is polar. Bond order = $(2-0)/2 = 1$. Option B is correct.

Q36. Which theory predicts the bent geometry of SO_2?

(A) Hybridization Theory

(B) VSEPR Theory

(C) Molecular Orbital Theory

(D) Valence Bond Theory

Answer: B. VSEPR Theory 5. Calculate the lone pair repulsion energy for NH_3 (AX_3E). Given: q = 0.5e, r = 1.43 Å. Answer: Erep = 1.6×10^{-18} J/mol.

Q37. In the Hückel Molecular Orbital theory for Butadiene, the energy levels are:

(A) $\alpha \pm \beta, \alpha \pm 2\beta$

(B) $\alpha \pm 0.618\beta, \alpha \pm 1.618\beta$

(C) $\alpha \pm \sqrt{(2)}\beta, \alpha \pm \sqrt{(3)}\beta$

(D) $\alpha \pm 0.5\beta, \alpha \pm 1.5\beta$

Answer: B. Roots of the secular determinant for butadiene are $\alpha \pm 1.618\beta$ and $\alpha \pm 0.618\beta$.

Q38. For the molecule $O2^{2-}$ (peroxide ion), the bond order is:

(A) 1

(B) 1.5

(C) 2

(D) 2.5

Answer: A. $O2^{2-}$ has total 18 electrons. Filling MOs: σ_{2s}^2,σ_{2s}^(2),σ_(2pz)²,π_(2p_x)²,π_(2py)²,π_(2p_x)^(2),π_(2py)^(2) (all filled). Bonding electrons = 10 (from σ_{2s},σ_(2pz),π_(2p_x,y) each 2, total 10?), careful: Actually for O2 (16 e), bond order=2. For $O2^{2-}$, add 2 electrons in antibonding π^, net bonding = 10 - 8 = 2, bond order=1. So A is correct.

Q39. Which of the following statements about sp^3 hybridisation is/are correct? 1. It involves the mixing of one s and three p orbitals. 2. The bond angles in sp^3 hybridised molecules are always 120°. 3. Ethane (C_2H_6) exhibits sp^3 hybridisation at carbon. 4. sp^3 hybridisation is observed in linear molecules like CO_2.

(A) All four statements

(B) Only 1 and 3

(C) Only 2 and 4

(D) Only 1 and 4

Answer: B. Correct (1 & 3): sp^3 hybridisation involves 1s + 3p orbitals (not 2s + 3p) and is observed in ethane (C_2H_6), where each carbon is tetrahedral (bond angles ~109.5°). Incorrect (2): Bond angles in sp^3 are ~109.5°, not 120° (that's sp^2). Incorrect (4): CO_2 is sp hybridised (linear, 180°), not sp^3. Key Concept: Hybridisation explains molecular geometry; sp^3 is tetrahedral. Tip: Remember sp^3 → 109.5°, sp^2 → 120°, sp → 180°.

Q40. Consider the following statements about optical properties of nanomaterials: 1. Quantum confinement in a semiconductor nanoparticle leads to a blue shift in the absorption onset as the particle size decreases. 2. Surface plasmon resonance (SPR) in metal nanoparticles is independent of particle shape. 3. The colour of gold nanoparticles changes from red to blue as particle size increases from ~10 nm to ~100 nm. Which of the statements given above is/are correct?

(A) 1 and 2 only

(B) 1 and 3 only

(C) 2 and 3 only

(D) 1, 2 and 3

Answer: B. Statement 1 is true (size decrease → larger bandgap → blue shift). Statement 2 is false: SPR depends on size, shape, and dielectric environment. Statement 3 is true: in spherical Au NPs, smaller (∼10 nm) appear red (SPR ~520 nm), larger (∼100 nm) appear blue/violet due to red-shifted and broadened SPR. Hence B.

Q41. Why is $BeSO_4$ highly soluble?

(A) $BeSO_4$ is ionic.

(B) Small size of Be^{2+} → high polarisation → hydration energy dominates.

(C) Large size of Be^{2+} → weak polarisation → lattice energy dominates.

(D) Be^{2+} forms covalent bonds with SO_4^{2-}.

Answer: B. Method: Polarising power of Be^{2+} → hydration energy > lattice energy.

Q42. Assertion (A): The Born-Haber cycle for NaCl yields a lattice energy of about –788 kJ mol^{-1}. Reason (R): The lattice energy can be measured directly by calorimetry.

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

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

(C) A is true, but R is false.

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

Answer: C. A is true, but R is false (lattice energy is calculated indirectly; it cannot be measured directly because gaseous ions cannot be isolated).

Q43. Considering the molecular orbital diagram of N_2, which of the following species has the highest bond dissociation energy?

(A) N_2^+

(B) N_2

(C) N_2^{2-}

(D) N_2^-

Answer: B. N_2 has bond order 3 (10 bonding – 4 antibonding)/2 = 3. N_2^+: bond order = 2.5; N_2^-: bond order = 2.5; N_2^{2-}: bond order = 2. Bond dissociation energy $\propto$ bond order. N_2 with bond order 3 has the highest.

Q44. Why does ferrocene $(C_5H_5)_2Fe$ exhibit diamagnetism?

(A) π-Back-donation

(B) d^2sp^3 hybridization

(C) sp^3 hybridization

(D) sp^2 hybridization

Answer: B. d^2sp^3 hybridization Sol.: Fe^{2+} has d^6 configuration, and d^2sp^3 hybridization ensures no unpaired electrons.

Q45. The correct order of bond angles in the following species is:

(A) $NH_3 > H_2O > CH_4$

(B) $CH_4 > NH_3 > H_2O$

(C) $H_2O > NH_3 > CH_4$

(D) $CH_4 > H_2O > NH_3$

Answer: B. CH_4: no lone pairs – perfect tetrahedral 109.5°. NH_3: one lone pair – angle reduced to ~107°. H_2O: two lone pairs – angle reduced to ~104.5°. Hence $CH_4 > NH_3 > H_2O$.

Q46. Which of the following molecules has the highest lattice energy?

(A) KBr

(B) MgO

(C) CsI

(D) NaCl

Answer: B. Lattice energy $\propto (q^+ \cdot q^-)/(r^+ + r^-)$. MgO has divalent ions (Mg^{2+}, O^{2-}) and small radii, leading to highest lattice energy. NaCl, KBr, CsI all are monovalent and larger.

Q47. Which of the following statements about the limitations of valence bond theory is/are correct? (i) It cannot explain the paramagnetism of O_2. (ii) It fails to account for delocalized bonding in molecules like benzene. (iii) It does not provide a quantitative measure of bond strength. (iv) It cannot describe molecules with fractional bond orders.

(A) (i) and (iv) only

(B) (i), (ii), (iii) and (iv)

(C) (ii) and (iii) only

(D) (i), (ii) and (iii) only

Answer: B. (i) Correct: VB theory predicts all electrons paired in O_2, contradicting its paramagnetism. (ii) Correct: VB struggles with resonance and delocalization. (iii) Correct: VB is qualitative; MO gives bond orders quantitatively. (iv) Correct: Fractional bond orders (e.g., in O_2^+) are naturally explained by MO. Parent theory: Criticisms and limitations of valence bond theory. Exam tip: MO theory handles paramagnetism and fractional bond orders naturally. Here are 25 advanced, exam-standard MCQs (26–50) for Chemical Bonding, Molecular Structure, and Solid State, covering all specified subtopics with rigorous conceptual depth and question-type variety:

Q48. Assertion (A): The molecule He_2 does not exist. Reason (R): According to MO theory, He_2 has bond order = 0.

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

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

(C) A is true, but R is false.

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

Answer: A. Both A and R are true, and R correctly explains A.

Q49. The Pauling electronegativity of carbon is 2.55 and that of chlorine is 3.16. The percentage ionic character of the C–Cl bond in CCl_4 is approximately:

(A) 6%

(B) 20%

(C) 12%

(D) 30%

Answer: C. Pauling formula: % ionic character = 100 × [1 – exp(–0.25($\Delta\chi$)²)] $\Delta\chi$ = 3.16 – 2.55 = 0.61 ($\Delta\chi$)² = 0.3721 0.25 × 0.3721 = 0.093 exp(–0.093) ≈ 0.911 % ionic = 100 × (1 – 0.911) = 8.9% ≈ 12% Parent concept: Bond polarity and ionic character. Exam tip: For $\Delta\chi$ < 1.7, the bond is mostly covalent; for higher, ionic.

Q50. Assertion (A): In molecular orbital theory, the number of molecular orbitals formed is equal to the number of atomic orbitals combined. Reason (R): Each atomic orbital overlaps with another to form a bonding and an antibonding orbital, conserving the total number of orbitals. Which of the following is correct?

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

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

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

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

Answer: C. Why A and R are true: When two atomic orbitals combine, they form two molecular orbitals (one bonding, one antibonding). This is a fundamental principle of MO theory. Why R explains A: The overlap mechanism directly results in the formation of two orbitals from two atomic orbitals. Parent Theory: Molecular orbital formation; orbital overlap. Exam Tip: For n atomic orbitals, n molecular orbitals are formed (n bonding + n antibonding).

Q51. For CH_4, which of the following describes its hybridization and geometry?

(A) sp^3 hybridization, tetrahedral

(B) sp^2 hybridization, trigonal planar

(C) sp hybridization, linear

(D) sp^3d hybridization, octahedral

Answer: A. sp^3 hybridization: 1 s + 3 p orbitals mix to form 4 sp^3 hybrid orbitals. Tetrahedral geometry: 4 bonding pairs arrange at 109.5° angles. Why B/C/D are wrong: CH_4 has no lone pairs, so no trigonal planar/linear/octahedral.

Q52. In the molecule SO2, the bond order of the S–O bonds, considering resonance, is:

(A) 1.5

(B) 2.0

(C) 1.0

(D) 2.5

Answer: A. SO2 has resonance between two equivalent structures: S=O (double bond) and S–O (single bond with formal charges). The average bond order per S–O bond is (2+1)/2 = 1.5. So A is correct.

Q53. Assertion (A): The Born-Haber cycle for NaCl predicts that lattice energy is directly proportional to the sum of ionic radii of Na^+ and Cl^-. Reason (R): The Born-Haber cycle accounts for enthalpy changes of formation, sublimation, ionization, electron affinity, and lattice formation, but lattice energy itself is derived from Coulomb's law and Born-Landé equation.

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

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

(C) Both A and R are true, but R is NOT the correct explanation of A.

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

Answer: A. A is false: Lattice energy is inversely proportional to the sum of ionic radii (smaller radii → stronger attraction → higher lattice energy). The Born-Haber cycle uses lattice energy as a calculated term, not a direct proportionality. R is true: The Born-Haber cycle indeed accounts for all listed enthalpy changes, and lattice energy is derived from Coulomb's law ($E \propto -q_1q_2/r$)