Name: _____ **Date:** _____

Answer Key: Bonding Beyond the Basics: Conquer Chemical Complexity for Grade 12

Analyze molecular geometry and orbital hybridization to predict how advanced chemical structures behave in industrial synthesis and pharmacological design.

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1. In the coordination complex [Ni(CN)4]2-, the nickel center exhibits dsp2 hybridization. Based on Crystal Field Theory and hybridization, what is the predicted geometry and magnetic property of this ion?

Answer: B) Square Planar and Diamagnetic

Nickel(II) is a d8 system. With strong-field ligands like CN-, the electrons pair up in the d-orbitals to allow dsp2 hybridization, resulting in a square planar geometry and no unpaired electrons (diamagnetic).

2. The molecule Xenon Tetrafluoride (XeF4) contains two lone pairs on the central atom. According to VSEPR theory, these lone pairs occupy the _____ positions to minimize repulsion.

Answer: A) Axial

In an octahedral electron geometry (AX4E2), lone pairs occupy opposite axial positions (180 degrees apart) to minimize electron-electron repulsion, resulting in a square planar molecular shape.

3. According to Molecular Orbital Theory, the O2 molecule is diamagnetic because all of its electrons are paired in the pi-bonding and sigma-bonding orbitals.

Answer: B) False

False. Molecular Orbital Theory correctly predicts O2 is paramagnetic because it has two unpaired electrons in the pi-star (antibonding) orbitals, following Hund's Rule.

4. Which of the following molecules transitions from sp3 to sp2 hybridization at the central carbon atom during a nucleophilic substitution (SN2) transition state?

Answer: C) Chloromethane

In an SN2 reaction, the tetrahedral carbon (sp3) passes through a pentacoordinate transition state where the carbon effectively adopts an sp2-like geometry with a p-orbital interacting with the nucleophile and leaving group.

5. In the context of Metallic Bonding, the transition from a conductor to an insulator as temperature increases in certain oxides is often explained by the _____ model.

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Answer: C) Band Theory

Band Theory explains conductivity by looking at the energy gap between the valence band and the conduction band; temperature effects and doping manipulate these gaps.

6. Which molecule possesses a formal charge of zero on the central atom but violates the octet rule by having an expanded valence shell?

Answer: B) SF6

Sulfur in SF6 uses d-orbitals to accommodate 12 electrons. Its formal charge is 6 (valence) - 0 (lone pair electrons) - 6 (bonds) = 0.

7. A sigma (σ) bond is generally stronger than a pi (π) bond because the orbital overlap in a sigma bond occurs along the internuclear axis, creating a higher electron density between the nuclei.

Answer: A) True

Sigma bonds involve end-to-end overlap which is more effective than the side-by-side overlap of p-orbitals in pi bonds, leading to a lower potential energy and stronger bond.

8. The concept used to describe molecules like ozone (O3) where a single Lewis structure cannot accurately represent the electron distribution is known as _____.

Answer: A) Resonance

Resonance structures are used when delocalized electrons exist; the actual molecule is a hybrid of these structures, with equal bond lengths.

9. When comparing Lattice Energy (U), which of the following ionic solids would be expected to have the highest magnitude of lattice energy?

Answer: D) ScN

Lattice energy is proportional to (Q1*Q2)/r. Scandium Nitride (ScN) has charges of +3 and -3, which significantly increases the attractive forces compared to the +1/-1 or +2/-2 ions in the other options.

10. The bond angle in NF3 is larger than the bond angle in NH3 because Fluorine is more electronegative than Hydrogen.

Answer: B) False

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False. In NF_3, the highly electronegative F atoms pull the bonding electrons further away from the Nitrogen, reducing the repulsion between bonding pairs. This allows the lone pair on N to compress the bond angle more in NF_3 (~102°) than in NH_3 (~107°).