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Answer Key: Bonding Battles: The Molecular Wrestling Federation for 11th Grade

Examine how electronegativity and orbital hybridization dictate the industrial strength of materials and the behavior of complex drugs.

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1. In a molecule of Gallium Arsenide (GaAs), often used in high-frequency semiconductors, how should the bonding character be categorized based on the Pauling scale of electronegativity (Ga = 1.81, As = 2.18)?

Answer: B) Predominantly covalent with significant polar character

The electronegativity difference is 0.37 (2.18 - 1.81). This is below the 1.7 threshold for ionic bonding but represents a polar covalent interaction where electrons are shared unequally, critical for semiconductor properties.

2. The extremely high melting point and hardness of Tungsten Carbide (WC), used in industrial cutting tools, is best explained because it forms a _____ lattice involving both covalent and metallic characteristics.

Answer: C) interstitial alloy

Tungsten Carbide is an interstitial alloy where carbon atoms fill the spaces (interstices) between larger tungsten atoms, creating a rigid structure that combines the directionality of covalent bonds with metallic strength.

3. According to Valence Shell Electron Pair Repulsion (VSEPR) theory, the presence of lone pairs on the central atom in Sulfur Tetrafluoride (SF4) results in a perfectly symmetrical tetrahedral geometry.

Answer: B) False

SF4 has five electron domains (one lone pair and four bonding pairs), resulting in a 'seesaw' molecular geometry rather than a symmetrical tetrahedron.

4. Why does Aluminum Chloride (AlCl3) exhibit a high degree of covalent character despite being composed of a metal and a non-metal?

Answer: B) Aluminum's high charge density polarizes the Chlorine electron cloud

Fajans' Rules state that a small cation with a high charge (Al3+) can distort the electron cloud of a large anion (Cl-), leading to orbital overlap and covalent behavior, such as subliming at low temperatures.

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5. In the process of carbon steel production, carbon is added to iron to impede the movement of layers in the metallic lattice. This structural modification results in an _____ alloy.

Answer: A) interstitial

Carbon atoms are significantly smaller than iron atoms, allowing them to sit in the gaps (interstices) of the iron lattice, making the metal harder and less ductile.

6. Consider the molecule Boron Trifluoride (BF3). Which statement best describes its bonding status in terms of the octet rule and formal charge?

Answer: B) It is electron-deficient, leaving Boron with only six valence electrons

Boron is a common exception to the octet rule; it is stable with only six electrons in its valence shell, making BF3 a potent Lewis acid (an electron-pair acceptor).

7. Diamond and Graphite are both allotropes of carbon, but Diamond is an insulator because its electrons are localized in sp3 hybrid orbitals, while Graphite conducts because of delocalized electrons in p-orbitals.

Answer: A) True

Graphite uses sp2 hybridization, leaving one p-orbital per carbon atom to form a delocalized pi-system that allows electron movement across layers. Diamond's sp3 orbitals lock electrons into rigid sigma bonds.

8. The strength of a chemical bond can be quantified by its 'bond order.' For the Nitrogen molecule (N2), the bond order is _____, which explains its extreme chemical inertness.

Answer: C) three

Nitrogen atoms share three pairs of electrons to form a triple bond (one sigma and two pi bonds). This high bond order makes it exceptionally stable and difficult to break without catalysts.

9. Which of the following compounds displays the highest lattice energy, as predicted by Coulomb's law of electrostatic attraction?

Answer: C) ScN (Scandium Nitride)

Lattice energy increases with the product of the ionic charges and decreases with ion size. Scandium (+3) and Nitride (-3) have a charge product of 9, significantly higher than MgO (4) or LiF (1).

10. All polar molecules must contain polar bonds, and all molecules with polar bonds are invariably polar molecules.

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Answer: B) False

While polar molecules require polar bonds, the inverse is false. Symmetrical molecules like CCl4 contain polar C-Cl bonds, but the dipoles cancel out, resulting in a non-polar molecule.