

Part I: Multiple Choice Questions (100 Points) There is *only* one best answer for each question.

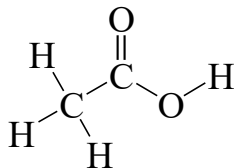
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- Which of the following statements are CORRECT?
 - Ionic bonds form when one or more valence electrons are transferred from one atom to another.
 - Covalent bonds involve sharing of electrons between atoms.
 - Ionic bond formation is always exothermic; covalent bond formation is always endothermic.
 - 1 only
 - 2 only
 - 3 only
 - 1 and 2
 - 1, 2, and 3
 - Which of the following compounds is expected to have the strongest ionic bonds?
 - MgO
 - KBr
 - NaI
 - SrO
 - CaS
 - What is the total number of valence electrons in a carbonate ion?
 - 20
 - 22
 - 24
 - 26
 - 30
 - Which of the following species will have a Lewis structure most like that of the hydronium ion, H_3O^+ ?
 - NO_3^-
 - NH_3
 - SO_3
 - CO_3^{2-}
 - H_2CO
 - How many resonance structures can be drawn for the thiocyanate ion, SCN^- ? The carbon atom is in the center of this ion.
 - 1
 - 2
 - 3
 - 4
 - 5
 - The central atom in XeF_4 is surrounded by
 - 3 single bonds, 1 double bond, and no lone pairs of electrons.
 - 2 single bonds, 2 double bonds, and no lone pairs of electrons.
 - 3 single bonds, 1 double bond, and 1 lone pair of electrons.
 - 4 single bonds, no double bonds, and no lone pairs of electrons.
 - 4 single bonds, no double bonds, and 2 lone pairs of electrons.

7. Use VSEPR theory to predict the electron-pair geometry and the molecular geometry of iodine trichloride, ICl_3 .
- The e--pair geometry is trigonal-planar, the molecular geometry is trigonal-planar.
 - The e--pair geometry is tetrahedral, the molecular geometry is trigonal-pyramidal.
 - The e--pair geometry is tetrahedral, the molecular geometry is trigonal-planar.
 - The e--pair geometry is trigonal-bipyramidal, the molecular geometry is T-shaped.
 - The e--pair geometry is trigonal-bipyramidal, the molecular geometry is trigonal-planar.
8. What is the formal charge on each atom in a hypobromite ion, OBr^{-1} ?
- $\text{O} = -2$, $\text{Br} = -1$
 - $\text{O} = -2$, $\text{Br} = +1$
 - $\text{O} = -1$, $\text{Br} = +1$
 - $\text{O} = -1$, $\text{Br} = 0$
 - $\text{O} = 0$, $\text{Br} = -1$
9. When heated, azomethane decomposes into nitrogen and ethane gas: $\text{CH}_3\text{N}=\text{NCH}_3(\text{g}) \rightarrow \text{N}_2(\text{g}) + \text{C}_2\text{H}_6(\text{g})$ Using this equation and the table of bond enthalpies below, calculate the enthalpy of reaction.

<u>Bond</u>	<u>Bond Energy</u> (kJ/mol)	<u>Bond</u>	<u>Bond Energy</u> (kJ/mol)
C-H	413	N-N	163
C-N	305	N=N	418
C-C	346	N \equiv N	945

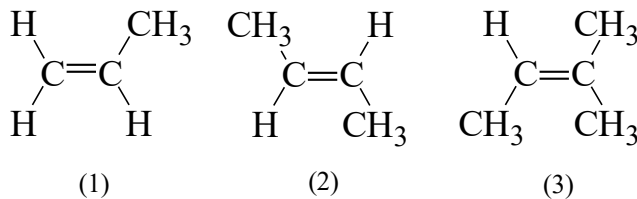
- 611 kJ
 - 527 kJ
 - 429 kJ
 - 313 kJ
 - 263 kJ
10. Based on bond order, predict which molecule has the shortest carbon-oxygen bond length.
- CO
 - CO₂
 - CH₃OH
 - H₂CO
 - O₃
11. All of the following statements concerning valence bond (VB) and molecular orbital (MO) bond theories are correct EXCEPT
- MO theory predicts that electrons are delocalized over the molecule.
 - in VB theory, bonding electrons are localized between pairs of atoms.
 - VB theory describes a molecular bond as the overlap between two atomic or hybrid orbitals.
 - MO theory can describe molecular bonding in excited states.
 - VB theory is used to predict the colors of compounds.

12. How many sigma (σ) bonds and pi (π) bonds are in acetic acid?



- six σ and one π
 - six σ and two π
 - seven σ and one π
 - eight σ and zero π
 - eight σ and one π
13. What is the hybridization of the sulfur atom in SF_4 ?
- sp
 - sp^2
 - sp^3
 - sp^3d
 - sp^3d^2
14. In which of the following molecules and ions does the central carbon atom have sp hybridization: Cl_2CO , CH_2Br_2 , CO_2 , and OCN^{-1} ?
- Cl_2CO only
 - Cl_2CO and CH_2Br_2
 - CH_2Br_2 and CO_2
 - CH_2Br_2 and OCN^{-1}
 - CO_2 and OCN^{-1}
15. What is the molecular geometry around a central atom that is sp^2 hybridized, has three sigma bonds, and has one pi bond?
- trigonal-planar
 - trigonal-pyramidal
 - trigonal-bipyramidal
 - linear
 - tetrahedral
16. Carbon dioxide reacts with an aqueous solution of sodium hydroxide to form carbonate ion. What change in the hybridization of carbon occurs in this reaction?
- sp to sp^2
 - sp^2 to sp^3
 - sp^3 to sp^3d
 - sp^3 to sp^3d^2
 - no change

17. For which of the following compounds is it possible for cis and trans isomers to exist?



- a. 1 only
- b. 2 only
- c. 3 only
- d. 1 and 2
- e. 1, 2, and 3

18. Atomic orbitals combine most effectively to form molecular orbitals when

- a. electrons in the orbitals have no spins.
- b. electrons in the orbitals have the same spin.
- c. the atomic orbitals are hybridized.
- d. the atomic orbitals have similar energies.
- e. metals combine with nonmetals.

19. According to molecular orbital theory, which of the following species is the most likely to exist?

- a. H_2^{2-}
- b. He_2
- c. Li_2
- d. Li_2^{2-}
- e. Be_2

20. According to molecular orbital theory, what is the bond order of superoxide, O_2^{-1} ?

- a. 1
- b. $3/2$
- c. 2
- d. $5/2$
- e. 3

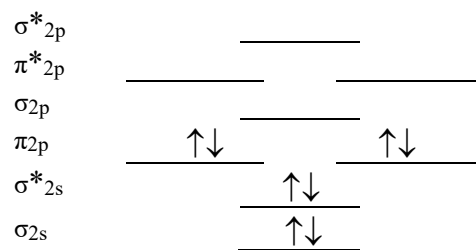
21. Use molecular orbital theory to predict which ion is diamagnetic.

- a. C_2^{2-}
- b. O_2
- c. NO
- d. N_2^{-1}
- e. B_2^{-1}

22. What is the molecular orbital configuration of CO?

- a. $[\text{core electrons}] (\sigma_{2s})^2 (\sigma_{2s}^*)^2 (\pi_{2p})^4$
- b. $[\text{core electrons}] (\sigma_{2s})^2 (\sigma_{2s}^*)^2 (\pi_{2p})^2 (\sigma_{2p})^2 (\pi_{2p}^*)^2$
- c. $[\text{core electrons}] (\sigma_{2s})^2 (\sigma_{2s}^*)^2 (\pi_{2p})^4 (\sigma_{2p})^2$
- d. $[\text{core electrons}] (\sigma_{2s})^2 (\sigma_{2s}^*)^2 (\sigma_{2p})^2 (\pi_{2p})^4$
- e. $[\text{core electrons}] (\sigma_{2s})^2 (\sigma_{2s}^*)^2 (\pi_{2p})^2$

23. Which molecule will have the following valence molecular orbital level energy diagram?



- a. Li_2
- b. Be_2
- c. B_2
- d. C_2
- e. N_2

24. Which of the following molecules may be a cycloalkane?

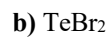
- a. C_3H_8
- b. C_4H_6
- c. C_5H_{12}
- d. C_6H_{12}
- e. C_7H_{16}

25. What is the molecular formula for heptane?

- a. C_6H_{12}
- b. C_6H_{14}
- c. C_7H_{14}
- d. C_7H_{16}
- e. C_8H_{14}

Part II: Short Answer / Calculation. *Show all work!*

1. For each of the following molecules or ions,
- draw the Lewis structure
 - give the hybridization of the central atom
 - predict the electron pair *and* molecular shape of the molecule, and
 - state if the molecule is polar or nonpolar



2. Draw molecular orbital energy diagrams for N_2 , N_2^{1+} and N_2^{1-} . Determine the bond order and indicate if each molecule is paramagnetic or diamagnetic. Indicate which of the molecules will have the shortest bond length.

3. Provide the correct name for each of the following compounds.

C_2H_6 _____

C_2H_4 _____

C_2H_2 _____

CH_3CH_2OH _____

CH_3OCH_3 _____

CH_3COCH_3 _____

CH_3CHO _____

C_6H_6 _____

CH_3OH _____

NH_3 _____