

Advanced Theories of Bonding Sample Multiple Choice Questions Fall 2022

The number of sample questions does not reflect the number of questions that may appear on an In-term test.

1. In a Valence Bond description of bonding, the molecule $\text{H}_3\text{C}-\text{C}\equiv\text{C}-\text{H}$ has the following total number of hybridized orbitals:

A. 2 B. 4 C. 6 D. 8 E. 10

2. Which of the following statements is/are CORRECT for metallic bonding?

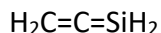
- i) Bonding electrons in metals are free to move from one bonding region to another.
- ii) Bonding theory for metals must include highly directional bonds as for molecules.
- iii) The energy gap (band gap) between occupied and unoccupied molecular orbitals is largest for an insulator.
- iv) There are no antibonding molecular orbitals for a semiconductor.

A. i only B. i and ii C. ii and iii D. i and iii E. ii and iv

3. Butyne, $\text{H}_3\text{C}-\text{C}\equiv\text{C}-\text{CH}_3$, has how many sigma (σ) and how many pi (π) bonds?

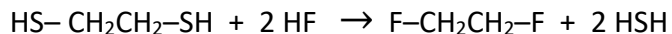
A. 8 σ , 0 π B. 5 σ , 1 π C. 5 σ , 3 π D. 9 σ , 2 π E. 6 σ , 2 π

4. What is the orbital hybridization assigned to the two C atoms and the Si atom in the molecule below, in order from left to right?



- A. sp^2 , sp , sp^3
- B. sp^3 , sp , sp^2
- C. sp^2 , sp^2 , sp^2
- D. sp , sp , sp^2
- E. sp^2 , sp , sp^2

5. Using bond enthalpies (given as Average Bond Energies in the Data Sheet) estimate the enthalpy change (ΔH , heat of reaction), in kJ mol^{-1} , for the following gas-phase reaction. (The bond energy value for S-C is 259 kJ mol^{-1} and that for S-H is 339 kJ mol^{-1} .)



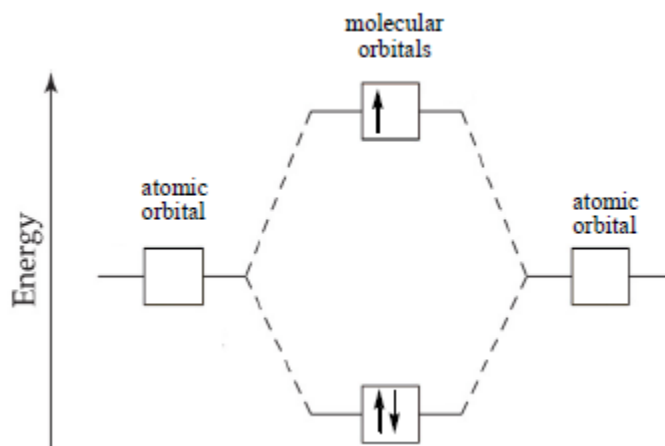
A. +824 kJ B. 0 kJ C. -824 D. -160 E. +160

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6. Which of the following statements is INCORRECT?

- A. The bonding in a linear arrangement of electron regions can often be rationalized using sp hybrid orbitals.
- B. When assigning the orbital hybridization, only bonding electrons are considered, since lone pairs do not participate in hybridization.
- C. In the molecule $H_2C=O$ the $H-C-O$ bond angles are slightly greater than 120° .
- D. Double bonds take up more space than single bonds.
- E. In NF_3 there are bond angles that are slightly less than the regular tetrahedral angle of 109.5° .

7. Consider the following molecular orbital energy diagram, which applies to diatomic species that use only $1s$ orbitals.



The MO diagram shown above can represent the electron energy levels for which of the following real or hypothetical molecule(s) or ion(s)?

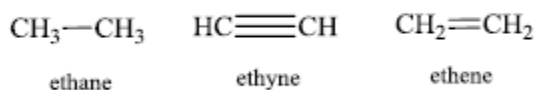
- | | | | | |
|------------|--------------|---------------|-----------------|-------------------|
| i. H_2^- | ii. He_2^+ | iii. He_2^- | iv. HHe | v. H_2 |
| A. i only | B. ii only | C. iv only | D. i, ii and iv | E. ii, iii and iv |

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8. Tungsten (W) has the highest melting point of all the pure metals (3422 °C). Using your knowledge of metallic bonding, choose the best explanation for this fact from the selection below.

- A. Tungsten has electrons in the 5d subshell.
- B. Tungsten's molecular orbitals form a continuous band.
- C. Tungsten has a half-filled s-d molecular orbital band, so the bonding between atoms is of maximum strength.
- D. Tungsten has as many anti-bonding electrons as bonding electrons, so the bonding between atoms is of maximum strength.
- E. Tungsten has a large first ionization energy, so it will not form an ionic lattice.

9. Consider the following molecules which contain carbon-carbon bonds: ethane (C₂H₆), ethyne (C₂H₂), and ethene (C₂H₄). The correct ordering in terms of carbon-carbon bond length is: (Where A>B means the carbon-carbon bond in A is longer than that in B.)



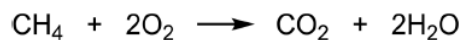
- A. ethyne > ethene > ethane
- B. ethyne > ethane > ethene
- C. ethene > ethyne > ethane
- D. ethane > ethyne > ethene
- E. ethane > ethene > ethyne

10. Which experimental observation of the O₂ molecule can NOT be explained by simple valence bond theory, and requires instead the application of molecular orbital (MO) theory?

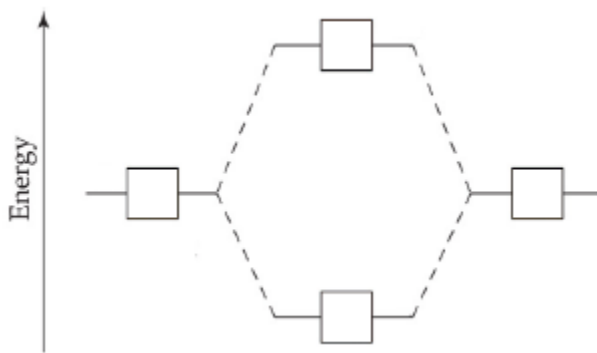
- A. That it exhibits an oxygen-oxygen double bond
- B. That it has a sigma (σ) bond and a pi (π) bond
- C. That the oxygen-oxygen distance is shorter than a single bond
- D. That liquid oxygen is attracted to the poles of a strong magnet
- E. That oxygen is non-polar

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11. Using average bond energies from the data sheet calculate the enthalpy change ΔH for the following reaction (in kJ). You may assume all reactants and products are gases.



- A. -1321 B. -521 C. -26 D. -48 E. -826
12. Predict which of the following metals will have the highest melting point.
- A. Cs B. Ba C. Ir D. Ta E. Au
13. Use the following molecular orbital energy diagram to determine the bond order in the H_2^- anion.



- A. 0 B. 0.5 C. 1.0 D. 1.5 E. 2.0
14. How many sigma (σ) bonds and how many pi (π) bonds are there in the following molecule?
- $$\begin{array}{c} \text{H} & & \text{O} & & \text{H} \\ | & & || & & | \\ \text{H}-\text{C} & -\text{C}\equiv\text{C}- & \text{C}-\text{O}- & \text{C}-\text{H} \\ | & & & & | \\ \text{H} & & & & \text{H} \end{array}$$
- A. 10 σ , 2 π B. 10 σ , 3 π C. 10 σ , 5 π D. 12 σ , 2 π E. 12 σ , 3 π

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15. What is the hybridization at antimony in $[\text{SbF}_4]^+$?

A. sp^3

B. sp^2

C. sp

D. sp^3d

E. sp^3d^2

Question	Answer
1	D
2	D
3	D
4	E
5	B
6	B
7	D
8	C
9	E
10	D
11	E
12	D
13	B
14	E
15	A