|  |
| --- |
| **Multiple Choice** |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 1. What is the molecular formula of limonene, the major volatile compound in orange peel oil?   |  |  |  | | --- | --- | --- | |  | a. | C10H18 | |  | b. | C10H20 | |  | c. | C10H16 | |  | d. | C11H14 | |  | e. | C11H18 |  |  |  | | --- | --- | | *ANSWER:* | c | |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 2. Of those indicated, which would be the shortest carbon-carbon bond in -selinene?   |  |  |  | | --- | --- | --- | |  | a. | A | |  | b. | B | |  | c. | C | |  | d. | D | |  | e. | E |  |  |  | | --- | --- | | *ANSWER:* | b | |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 3. What would be the ideal value for the indicated bond angle?   |  |  |  | | --- | --- | --- | |  | a. | 120° | |  | b. | 90° | |  | c. | 104° | |  | d. | 180° | |  | e. | 109° |  |  |  | | --- | --- | | *ANSWER:* | e | |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 4. Which structure matches the following condensed structure?   |  |  |  | | --- | --- | --- | |  | a. |  | |  | b. |  | |  | c. |  | |  | d. |  | |  | e. |  |  |  |  | | --- | --- | | *ANSWER:* | a | |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 5. Which one of the following structures must be incorrect?   |  |  |  | | --- | --- | --- | |  | a. |  | |  | b. |  | |  | c. |  | |  | d. |  | |  | e. |  |  |  |  | | --- | --- | | *ANSWER:* | c | |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 6. Which of the following is **not** a resonance structure of the others?   |  |  |  | | --- | --- | --- | |  | a. |  | |  | b. |  | |  | c. |  | |  | d. |  | |  | e. |  |  |  |  | | --- | --- | | *ANSWER:* | e | |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 7. Which one of the resonance structures below would be the most important (i.e., most stable)?   |  |  |  | | --- | --- | --- | |  | a. |  | |  | b. |  | |  | c. |  | |  | d. |  | |  | e. |  |  |  |  | | --- | --- | | *ANSWER:* | d | |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 8. How many atoms in ethene are required by *sp*2 bonding to lie in the same plane?   |  |  |  | | --- | --- | --- | |  | a. | 2 | |  | b. | 3 | |  | c. | 4 | |  | d. | 5 | |  | e. | 6 |  |  |  | | --- | --- | | *ANSWER:* | e | |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 9. Which one of the following structures is not chemically identical to the others?   |  |  |  | | --- | --- | --- | |  | a. |  | |  | b. |  | |  | c. |  | |  | d. |  | |  | e. |  |  |  |  | | --- | --- | | *ANSWER:* | d | |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 10. Which of the following pairs are **not** resonance structures of each other?   |  |  |  | | --- | --- | --- | |  | a. |  | |  | b. |  | |  | c. |  | |  | d. |  | |  | e. | All are pairs of resonance structures. |  |  |  | | --- | --- | | *ANSWER:* | e | |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 11. How many hydrogen atoms are part of the following steroid?   |  |  |  | | --- | --- | --- | |  | a. | 18 | |  | b. | 20 | |  | c. | 21 | |  | d. | 22 | |  | e. | 24 |  |  |  | | --- | --- | | *ANSWER:* | e | |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 12. In the following molecule, how many carbon atoms are in the *sp*3 hybridization state?   |  |  |  | | --- | --- | --- | |  | a. | 2 | |  | b. | 4 | |  | c. | 5 | |  | d. | 6 | |  | e. | 11 |  |  |  | | --- | --- | | *ANSWER:* | d | |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 13. In the following molecule, how many carbon atoms are in the *sp*2 hybridization state?   |  |  |  | | --- | --- | --- | |  | a. | 0 | |  | b. | 1 | |  | c. | 2 | |  | d. | 4 | |  | e. | 6 |  |  |  | | --- | --- | | *ANSWER:* | d | |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 14. In the following molecule, how many carbon atoms are in the *sp* hybridization state?   |  |  |  | | --- | --- | --- | |  | a. | 2 | |  | b. | 4 | |  | c. | 6 | |  | d. | 12 | |  | e. | None of the above. |  |  |  | | --- | --- | | *ANSWER:* | e | |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 15. The lone-pair of electrons on nitrogen in the following molecule reside in what type of orbital?   |  |  |  | | --- | --- | --- | |  | a. | *sp*3  ​ | |  | b. | *sp*2  ​ | |  | c. | *sp* | |  | d. | 2*p* | |  | e. | 2*s* |  |  |  | | --- | --- | | *ANSWER:* | b | |

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| 16. In the following molecule, how many carbon atoms are in the *sp*2 hybridization state?   |  |  |  | | --- | --- | --- | |  | a. | 1 | |  | b. | 3 | |  | c. | 7 | |  | d. | 8 | |  | e. | 9 |  |  |  | | --- | --- | | *ANSWER:* | e | |

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| 17. The boxed item most likely represents what?   |  |  |  | | --- | --- | --- | |  | a. | *s* orbital | |  | b. | *sp*3 orbital | |  | c. | *p* orbital | |  | d. | could be any of A–C | |  | e. | None of the above. |  |  |  | | --- | --- | | *ANSWER:* | b | |

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| 18. The following molecule contains how many carbon atoms in the *sp* hybridization state?   |  |  |  | | --- | --- | --- | |  | a. | 1 | |  | b. | 3 | |  | c. | 8 | |  | d. | 13 | |  | e. | 16 |  |  |  | | --- | --- | | *ANSWER:* | a | |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 19. The nitrogen of trimethylamine [(CH3)3N] contains how many lone pairs of electrons?   |  |  |  | | --- | --- | --- | |  | a. | none | |  | b. | one | |  | c. | two | |  | d. | three | |  | e. | there is no nitrogen in this molecule |  |  |  | | --- | --- | | *ANSWER:* | b | |

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| 20. A positive charge on oxygen generally occurs when:   |  |  |  | | --- | --- | --- | |  | a. | oxygen has too many electrons. | |  | b. | oxygen has too few electrons. | |  | c. | oxygen is sharing one of its non-bonding electron pairs. | |  | d. | oxygen has too many non-bonding electron pairs. | |  | e. | oxygen is borrowing electrons from another atom. |  |  |  | | --- | --- | | *ANSWER:* | c | |

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| 21. The carbon atom in CH2Cl2 has what hybridization?   |  |  |  | | --- | --- | --- | |  | a. | *sp* | |  | b. | *sp*2 | |  | c. | *sp*3 | |  | d. | *sp*4 | |  | e. | they are not hybridized |  |  |  | | --- | --- | | *ANSWER:* | c | |

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| 22. The molecular formula for piperitone is   |  |  |  | | --- | --- | --- | |  | a. | C9H16O | |  | b. | C10H18O | |  | c. | C9H18O | |  | d. | C10H14O | |  | e. | C10H16O |  |  |  | | --- | --- | | *ANSWER:* | e | |

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| 23. Which structure is different from the others?   |  |  |  | | --- | --- | --- | |  | a. |  | |  | b. | CH3CHClCH(CH3)2  ​ | |  | c. |  | |  | d. |  | |  | e. | All are identical. |  |  |  | | --- | --- | | *ANSWER:* | e | |

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| 24. A fairly common algal metabolite is the compound (-)-geosmin, which imparts a musty odor to water even at concentrations in the ppb range. What is the molecular formula of geosmin?   |  |  |  | | --- | --- | --- | |  | a. | C11H20O | |  | b. | C12H22O | |  | c. | C11H21O | |  | d. | C12H20O | |  | e. | C12H21O |  |  |  | | --- | --- | | *ANSWER:* | b | |

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| 25. Which of the carbon-carbon bonds indicated would you expect to be the **longest** in stilbene?   |  |  |  | | --- | --- | --- | |  | a. | A | |  | b. | B | |  | c. | C | |  | d. | D | |  | e. | E |  |  |  | | --- | --- | | *ANSWER:* | d | |

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| 26. Which of the following pairs are **not** resonance structures of each other?   |  |  |  | | --- | --- | --- | |  | a. |  | |  | b. |  | |  | c. |  | |  | d. |  | |  | e. | All are pairs of resonance structures. |  |  |  | | --- | --- | | *ANSWER:* | a | |

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| 27. The following molecule has what molecular formula?   |  |  |  | | --- | --- | --- | |  | a. | C39H58O | |  | b. | C40H58O | |  | c. | C39H60O | |  | d. | C44H44O | |  | e. | None of the above. |  |  |  | | --- | --- | | *ANSWER:* | a | |

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| 28. What is the molecular formula of carvone, the major volatile compound in caraway oil?   |  |  |  | | --- | --- | --- | |  | a. | C10H18O | |  | b. | C10H17O | |  | c. | C10H16O | |  | d. | C10H14O | |  | e. | C10H15O |  |  |  | | --- | --- | | *ANSWER:* | d | |

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| 29. Of those indicated, which would be the shortest carbon-carbon bond in -cadinene?   |  |  |  | | --- | --- | --- | |  | a. | A | |  | b. | B | |  | c. | C | |  | d. | D | |  | e. | E |  |  |  | | --- | --- | | *ANSWER:* | a | |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 30. What would be the ideal value for the indicated bond angle?   |  |  |  | | --- | --- | --- | |  | a. | 120° | |  | b. | 90° | |  | c. | 104° | |  | d. | 180° | |  | e. | 109° |  |  |  | | --- | --- | | *ANSWER:* | a | |

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| 31. Which structure matches the following condensed structure?   |  |  |  | | --- | --- | --- | |  | a. |  | |  | b. |  | |  | c. |  | |  | d. |  | |  | e. |  |  |  |  | | --- | --- | | *ANSWER:* | d | |

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| 32. Which one of the following structures must be incorrect?   |  |  |  | | --- | --- | --- | |  | a. |  | |  | b. |  | |  | c. |  | |  | d. |  | |  | e. |  |  |  |  | | --- | --- | | *ANSWER:* | b | |

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| 33. How many *sp2* hybridized carbon atoms are in the potent anticancer compound hydroxymethylacylfulvene?   |  |  |  | | --- | --- | --- | |  | a. | 2 | |  | b. | 4 | |  | c. | 6 | |  | d. | 8 | |  | e. | None of the above. |  |  |  | | --- | --- | | *ANSWER:* | e | |

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| 34. In the following molecule, how many carbon atoms are in the *sp*3 hybridization state?   |  |  |  | | --- | --- | --- | |  | a. | 2 | |  | b. | 4 | |  | c. | 5 | |  | d. | 6 | |  | e. | 9 |  |  |  | | --- | --- | | *ANSWER:* | a | |

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| 35. Which of the following statements are true of sp orbitals?   |  |  |  | | --- | --- | --- | |  | a. | Orbitals of the *sp* type are 50% *s* and 50% *p* character. | |  | b. | They are hybrid orbitals. | |  | c. | They are linear. | |  | d. | They result when one *s* orbital and one *p* orbital are mixed. | |  | e. | All are correct. |  |  |  | | --- | --- | | *ANSWER:* | e | |

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| 36. Which of the following molecules are most likely to be held together by a purely covalent bond?   |  |  |  | | --- | --- | --- | |  | a. | NaCl | |  | b. | H2 | |  | c. | HF | |  | d. | BH3 | |  | e. | KI |  |  |  | | --- | --- | | *ANSWER:* | b | |

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| 37. What is the molecular formula of camphor?   |  |  |  | | --- | --- | --- | |  | a. | C10H15O | |  | b. | C10H16O | |  | c. | C10H17O | |  | d. | C11H18O | |  | e. | C11H16O |  |  |  | | --- | --- | | *ANSWER:* | b | |

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| 38. Camptothecin is an important anticancer compound; how many carbons are in the *sp* hybridization state?   |  |  |  | | --- | --- | --- | |  | a. | 0 | |  | b. | 1 | |  | c. | 2 | |  | d. | 3 | |  | e. | 4 |  |  |  | | --- | --- | | *ANSWER:* | a | |

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| 39. How many *sp*3 carbons are in the following molecule?   |  |  |  | | --- | --- | --- | |  | a. | 0 | |  | b. | 1 | |  | c. | 2 | |  | d. | 3 | |  | e. | 4 |  |  |  | | --- | --- | | *ANSWER:* | c | |

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| 40. The process of adding electrons one by one to atomic orbitals beginning with the lowest energy is described by:   |  |  |  | | --- | --- | --- | |  | a. | the Aufbau Principle. | |  | b. | Hund's Rule. | |  | c. | the de Broglie Relation. | |  | d. | the Pauli Exclusion Principle. | |  | e. | Coulomb's Law. |  |  |  | | --- | --- | | *ANSWER:* | a | |

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| 41. Which of the following cannot be a correct Lewis structure?   |  |  |  | | --- | --- | --- | |  | a. |  | |  | b. |  | |  | c. |  | |  | d. |  | |  | e. | All are correct. |  |  |  | | --- | --- | | *ANSWER:* | c | |

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| 42. How many different resonance structures can be drawn for the benzyl cation (shown below) which place the plus charge on a carbon atom in the ring?   |  |  |  | | --- | --- | --- | |  | a. | 1 | |  | b. | 2 | |  | c. | 3 | |  | d. | 5 | |  | e. | 6 |  |  |  | | --- | --- | | *ANSWER:* | c | |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 43. Which of the following represent resonance contributing Lewis structures for CH2N2?   |  |  |  | | --- | --- | --- | |  | a. |  | |  | b. |  | |  | c. |  | |  | d. |  | |  | e. | both A and B are correct |  |  |  | | --- | --- | | *ANSWER:* | e | |

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| 44. The following molecule belongs to a class of compounds known as allenes. Based on your knowledge of bonding, predict the hybridization of the carbon atom indicated by the arrow.   |  |  |  | | --- | --- | --- | |  | a. | *sp* | |  | b. | *sp*2 | |  | c. | *sp*3 | |  | d. | *p*-*p* pi | |  | e. | a hypervalent carbon |  |  |  | | --- | --- | | *ANSWER:* | a | |

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| 45. How many isomers of C4H9Br are possible?   |  |  |  | | --- | --- | --- | |  | a. | two | |  | b. | three | |  | c. | four | |  | d. | five | |  | e. | six |  |  |  | | --- | --- | | *ANSWER:* | c | |

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| 46. How many isomers of C5H12 are possible?   |  |  |  | | --- | --- | --- | |  | a. | two | |  | b. | three | |  | c. | four | |  | d. | five | |  | e. | six |  |  |  | | --- | --- | | *ANSWER:* | b | |

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| 47. Which of the following most correctly defines "structural isomers"?   |  |  |  | | --- | --- | --- | |  | a. | molecules with different molecular formulas but the same connectivity | |  | b. | compounds that are not constitutional isomers | |  | c. | molecules with the same molecular formula but different connectivity | |  | d. | *Anti* and *gauche* conformers | |  | e. | both B and C |  |  |  | | --- | --- | | *ANSWER:* | c | |

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| 48. How many structural isomers exist for the formula C6H14?   |  |  |  | | --- | --- | --- | |  | a. | 3 | |  | b. | 4 | |  | c. | 5 | |  | d. | 6 | |  | e. | 7 |  |  |  | | --- | --- | | *ANSWER:* | c | |

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| 49. A hydrocarbon with a double bond and a ring will have the general formula?   |  |  |  | | --- | --- | --- | |  | a. | C*n*H2*n*+2 | |  | b. | C*n*H2*n* | |  | c. | C*n*H2*n*-2 | |  | d. | C*n*H2*n*-4 | |  | e. | C2*n*H2*n* |  |  |  | | --- | --- | | *ANSWER:* | c | |

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| 50. What is the hybridization of the each of the labeled atoms for the potent neurotoxin (-)-gephyrotoxin?   |  |  |  | | --- | --- | --- | |  | a. | A = *sp*2, B = *sp*, C = *sp*2, D = *sp*3, E = *sp*3 | |  | b. | A = *sp*2, B = *sp*, C = *sp*3, D = *sp*3, E = *sp*2 | |  | c. | A = *sp*2, B = *sp*, C = *sp*2, D = *sp*3, E = *sp*2 | |  | d. | A = *sp*2, B = *sp*, C = *sp*3, D = *sp*3, E = *sp*3 | |  | e. | A = *sp*, B = *sp*, C = *sp*3, D = *sp*3, E = *sp*3 |  |  |  | | --- | --- | | *ANSWER:* | d | |