Entry Level Test

1. Organic chemistry is the study of compounds containing the chemical element _____.

2. Organic and inorganic compounds are different because the former contain a "vital force" and the latter do not.

   a. True
   b. False

3. Define the term "orbital."

4. Sketch the shape of a $2p_x$ orbital.

5. The plane passing between the two lobes of a p orbital is a region of zero electron density. It is called a _____ plane.

6. Only two electrons can occupy an orbital, and they must have opposite spin. This statement reflects _____.

   a. Hund's rule
   b. the Pauli exclusion principle

7. List the atomic orbitals from 1s to 3d in order of increasing energy.

8. What is the ground-state electron configuration of phosphorus (atomic number 15)?

9. In a molecule of methane, all of the atoms lie in the same plane.

   a. True
   b. False

10. Sketch the shape of a molecule of tetrachloromethane (CCl_4) using the "wedge-and-broken-line" method of representation.

11. Draw a ball-and-stick model of tetrabromomethane (CBr_4) to show its three-dimensional shape.

12. Without the aid of a periodic table, draw the Lewis structures of each of the molecules listed below.

    a. CH_2Cl_2
    b. H_2S
    c. NH_4^+

13. Without the aid of a periodic table, draw the Kekulé structure (structural formula) of each of the molecules listed in question 12 above.

14. Briefly explain the formation of a covalent bond in valence bond theory.

15. Identify the atomic orbitals which must overlap to form the covalent bonds present in each of the molecules listed below.

    a. fluorine

    b. hydrogen chloride

16. As *p* orbitals become larger, the efficiency with which they can overlap with an *s* orbital to form covalent bonds decreases. How would you expect this fact to influence the relative lengths and strengths of the bonds present in the hydrogen fluoride molecule and the hydrogen iodide molecule?

17. The mathematical mixing of one *s* orbital and three *p* orbitals to form four new orbitals is called _____.

18. a. Each of the four C—H bonds in methane is formed by the overlap of the 1*s* orbital of a hydrogen atom with _____ orbital of the central carbon atom.

    b. All of the bond angles in methane are _____.

19. Draw the Kekulé structure (structural formula) of ethane. Describe the type of bonds formed and the orbitals used to form them.

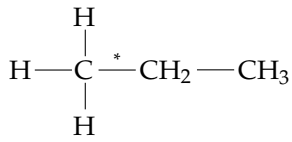
20. The carbon-carbon bond in ethylene consists of a _____ bond formed by the head-on overlap of two _____ hybrid orbitals, and a π bond formed by the _____ overlap of two _____ orbitals.

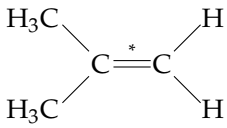
21. The triple bond in acetylene consists of a σ bond formed by the _____ overlap of two _____ hybrid orbitals, and two _____ bonds, each formed by the _____ overlap of two _____ orbitals.

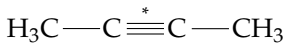
22. The carbon-hydrogen bonds in acetylene are each formed by the overlap of _____ orbital from a carbon atom and the _____ orbital of a hydrogen atom.

23. The H—C—C bond angle in ethane is _____, in ethylene _____, and in acetylene _____.

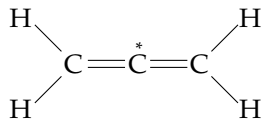
24. Predict the approximate length, in picometres (pm), of the carbon-carbon bonds marked with an asterisk (*) in each of the structures presented below.

a. 

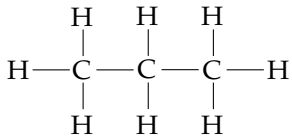
b. 

c. 

25. The C—C—C bond angle in the compound allene (shown below) is 180°. The central carbon atom (C*) in this compound is _____ hybridized. Do you expect the carbon-carbon bonds in allene to be longer or shorter than those in propane (shown below)?—weaker or stronger?



Allene



Propane

26. What type of hybridization would you predict for each of the nitrogen atoms in the compound hydrazine ($H_2N—NH_2$)?

27. What type of hybridization would you predict for each of the atoms listed below?

    a. phosphorus in PH_3
    b. oxygen in OF_2

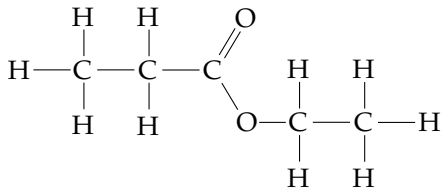
28. Draw a molecular orbital diagram for the fluorine molecule.

29. Draw two Kekulé structures (structural formulas) that correspond to each of the molecular formulas presented below.

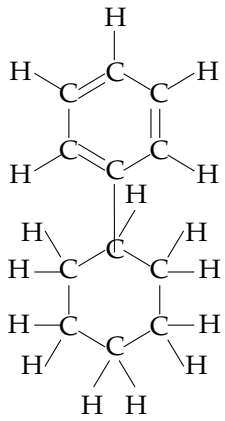
    a. C_2H_6O
    b. C_2H_7N

30. Write down the molecular formula that corresponds to each of the structural formulas presented below.

a.

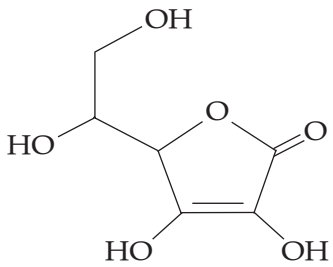


b.



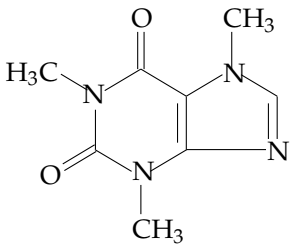
31. Draw the shorthand or skeletal structure of each of the compounds listed in question 30, above.

32. Vitamin C can be represented by the following shorthand or skeletal structure:



Draw the Kekulé structure that corresponds to this structure.

33. Determine the molecular formula of caffeine, given the following shorthand structure:



34. Construct ball-and-stick models of each of the compounds listed below.

    a. dichloromethane, CH_2Cl_2
    b. bromoethane, C_2H_5Br
    c. methanol, CH_3OH
    d. vinyl chloride, $CH_2{=}CHCl$
    e. acetylene, C_2H_2
    f. acetaldehyde, $CH_3C(=O)H$
    g. formic acid, $HC(=O)OH$