Valence, Bonding & Lewis Structures

1. Show the number of valence electrons in each of the following atoms. Let the element's symbol represent the core electron structure, and use dots for the valence electrons.
    a. calcium
    b. oxygen
    c. carbon

2. Use the relative positions of the elements in the periodic table to classify the following substances as ionic or covalent.
    a. F_2
    b. KI
    c. P_2O_5
    d. $SiCl_4$

3. When a solution of sodium chloride in water is treated with a silver nitrate solution, a white precipitate forms immediately. When tetrachloromethane is shaken with aqueous silver nitrate, no such precipitate is produced. Explain these facts in terms of the types of bonds present in the two chlorides.

4. For each of the following elements, determine the number of valence electrons and the common number of covalent bonds it will have.
    a. O
    b. H
    c. S

5. Write a structural formula for each of the following compounds, using a line to represent each single bond and dots for any lone pairs.
    a. CH_3CH_2OH
    b. CH_3F
    c. C_3H_8

6. Draw a structural formula for each of the following covalent molecules. Which bonds are polar? Indicate the polarity by proper placement of the symbols $\delta+$ and $\delta-$.
    a. HBr
    b. CH_3F
    c. CO_2
    d. Cl_2

7. Consider the X-H bond, in which X is an atom other than H. The H in a polar bond is more acidic than the H in a nonpolar bond. Considering bond polarity, write an equation for the reaction between acetic acid $CH_3\underset{\displaystyle OH}{\overset{\displaystyle |}{C}}=O$ and sodium hydroxide.

Structural Isomers

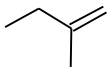
8. Draw structural isomers for all possible isomers having the following molecular formulas:
    a. C_3H_6
    b. C_3H_7Cl
    c. $C_2H_4F_2$
    d. C_3H_8

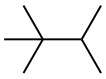
9. Draw structural isomers for the five isomers of hexane. As you write them, try to be systematic, starting with a consecutive chain of six carbon atoms.

Structural Formulas

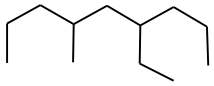
10. For each of the following abbreviated structural formulas, write a structural formula that shows all of the bonds:
    a. $CH_3(CH_2)_3CH_3$
    b. $(CH_3)_3CCH_2CH_3$
    c. $(CH_3)_2CHOH$

11. Write structural formulas that correspond to the following abbreviated structures, and show the correct number of hydrogens on each carbon:

a. 

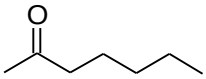
c. 

b. 

d. 

12. For each of the following abbreviated structural formulas, write a line-segment formula (like those in #11):
    a. $CH_3(CH_2)_4CH_3$
    b. $(CH_3)_2CH\ CH_2\ CH_2\overset{\overset{O}{\|}}{C}CH_3$

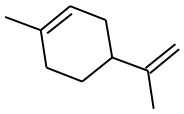
13. Whilst looking at the following abbreviated formula for 2-heptanone (oil of cloves), address a, b, and c.

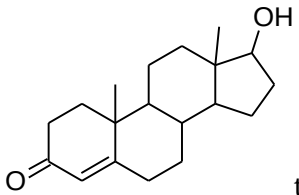


    a. How many carbons does 2-heptanone have?
    b. What is its molecular formula?
    c. Write a more detailed structural formula for it, as you did in #11.

14. What is the molecular formula for each of the following compounds:

a.  benzene

b.  limonene

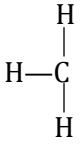
c. 

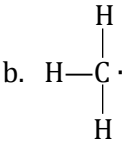
testosterone

Formal Charge, Resonance, and Curved-Arrow Formalism

15. Write the electron-dot formulas for the following species. Show where formal charges, if any, are located.
    a. nitrous acid, HONO
    b. nitric acid, $HONO_2$
    c. formaldehyde, H_2CO
    d. ammonium ion, NH_4^{1+}

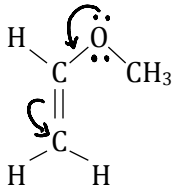
16. Consider the following highly reactive carbon species. What is the formal charge on carbon in each species?

a. 

b. 

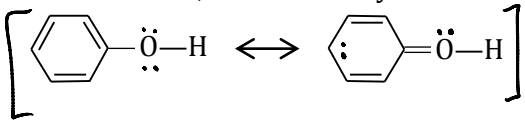
17. Draw electron-dot formulas for the two contributors to the resonance hybrid structure of the nitrite ion, NO_2^{1-}. Each oxygen is connected to the nitrogen. What is the charge on each oxygen in each contributor and in the hybrid structure? Show by curved arrows how the electron pairs can relocate to interconvert the two structures.

18. Write the structure obtained when electrons move as indicated by the curved arrows in the following structure:

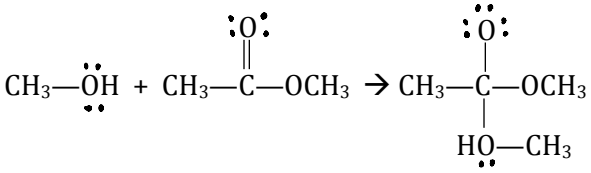


Does each atom in the resulting structure have a complete valence shell of electrons? Locate any formal charges in each structure.

19. Add curved arrows to the following structures to show how electron pairs must be moved to interconvert the structures, and locate any formal charges.



20. Add curved arrows to show how electrons must move to form the product from the reactants in the following equation, and locate any formal charges.



Electronic Structure and Molecular Geometry

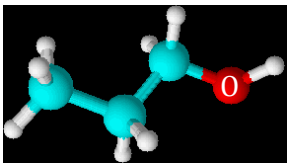
21. Fill in any unshared electron pairs that are missing from the following formulas:
    a. $(CH_3)_2NH$
    b. $CH_3C(=O)OH$

22. The ammonium ion, NH_4^{1+}, has a tetrahedral geometry analogous to that of methane. Explain this structure in terms of atomic and molecular orbitals.

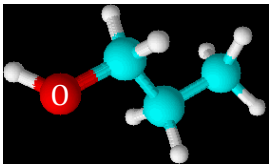
23. Use lines, dashed wedges, and solid wedges to show the geometry of CCl_4 and CH_3OH.

24. Silicon is just below carbon on the periodic table. Predict the geometry of silicon tetrachloride, $SiCl_4$.

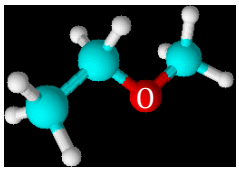
25. Examine the ball-and-stick models shown below:



A



B



C

    a. Redraw the three structures using solid lines, dashed wedges, and solid wedges.
    b. What is the relationship, identical or isomers, between structures A & B? Between structures A & C?

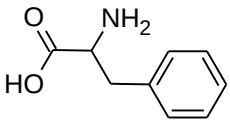
<u>Classification of Organic Compounds</u>

26. Write a structural formula that corresponds to the molecular formula C_4H_8O and is
    a. acyclic
    b. carbocyclic

27. Divide the following compounds into groups that might be expected to exhibit similar chemical behavior. Name those groups.
    a. C_5H_{12}
    b. CH_3NH_2
    c. C_4H_9OH
    d. CH_3OCH_3
    e. $HOCH_2CH_2OH$
    f. C_8H_{18}
    g. $H_2NCH_2CH_2NH_2$
    h. CH_3OH
    i. $(CH_3)_2CHNH_2$
    j. C_3H_7OH
    k. $CH_3CH_2CH_3$
    l. C_6H_{14}

28. Write a structural formula for each of the following:
    a. an alcohol, $C_4H_{10}O$
    b. an ether, C_3H_8O
    c. an aldehyde, C_3H_6O
    d. a ketone, C_4H_8O
    e. a carboxylic acid, $C_3H_6O_2$

29. Many organic compounds contain more than one functional group. An example is phenylalanine, shown below and one of the simple building blocks of proteins.



a. What functional groups are present in phenylalanine?
b. Redraw the structure, showing all atoms and lone pairs.
c. What is the molecular formula of phenylalanine?
d. Draw another structural isomer that has this formula. What functional groups does this isomer have?