Learning Objectives

**Covalent bonding**
- know the rules of valence and how they can be used to form simple molecules
- Know how to name simple covalently bonded molecules
- Know the names, formulas and charges of common polyatomic ions.
- Be able to recognize the type of bonding in molecules (ionic, covalent or both)
- Know the meaning of bond dissociation energy (BDE)
- Be able to predict the trend in bond length and strength based on bond order

**Electronegativity and Bond Polarity**
- Be able to compare and predict the relative electronegativity of elements.
- Recognize polar chemical bonds.
- Rank chemical bonds from least to greatest polarity.

**Draw Lewis Structures, Resonance, and Formal Charge**
- Given a chemical formula, be able to draw the Lewis structure using the octet rule
- Correctly illustrate multiple bonds with a Lewis structure.
- Be able to give the number of valence electrons, bonding electrons, and nonbonding electrons or lone pairs in a molecule.
- Be able to determine the formal charge of an atom in a Lewis structure.
- With similar Lewis structures, use formal charge to decide which structure is better.
- Recognize when a molecule has resonance and be able to draw the resonance structures.
- Recognize molecules that have exceptions to the octet rule.
- Understand the reasons for the exceptions to the octet rule (when it is possible or likely for these exceptions to occur).
- Be able to make connections between Lewis structures and properties (like bond length and strength).
- Rank bond length and strength using Lewis structures.
Week 5: 25 Sept thru 1 Oct; Lectures 13-15

Homework Problems
Due on Thurs. Oct. 3

1. Identify the following compounds as either molecular or ionic and name the compound. If they are ionic, determine the identity and charge of the component ions.
   I. MgH$_2$
   II. H$_2$O
   III. NH$_4$F
   IV. NaBr

2. Determine the correct formula and molecular weight for each of the following compounds:
   I. Iron (III) oxide
   II. Strontium nitride
   III. Ammonium chloride

3. Which of the following contains both ionic and covalent bonds?
   A. H$_3$PO$_4$
   B. NH$_3$
   C. CO$_2$
   D. KNO$_3$
   E. KCl

4. Which of the following formula–name combinations is(are) correct?
   1. NH$_4$Cl$_2$ ammonium chloride
   2. K$_2$CO$_3$ potassium carbonate
   3. Ca$_3$(PO$_4$)$_2$ calcium phosphate

   The correct combination(s) is(are)
   A. 1 only
   B. 2 only
   C. 1 and 3 only
   D. 2 and 3 only
   E. 1 and 2 only

5. Elements D, E, and G have atomic numbers Z, Z+1, and Z+2 respectively. E is a noble gas (not helium). Which statement is true?
   A. Elements D and G should form a compound which is a gas at room temperature and which has formula GD.
   B. Elements D and G should form a compound which is a solid at room temperature with formula GD.
   C. Elements D and G should not react with each other.
   D. Elements D and G should react to form a covalent compound with formula DG.
   E. None of the above is a true statement.

6. Using only the periodic table, select the most electronegative atom in each of the following sets:
   I. As, Se, Br, I;
   II. Al, B, C, Si;
   III. Ge, As, P, Sn;
   IV. Li, Rb, Be, Sr.

7. Put these in order of increasing electronegativity.
   Ca Si O Al Ba

8. Arrange the bonds in each of the following sets in order of increasing polarity:
   I. C—F, O—F, Be—F
   II. Be—Cl, Br—Cl, C—Cl
   III. C—Cl, C—O, C—H
9. The electronegativities of four elements (L, M, Q, and R) are as follows:
   
   L: 1.1  M: 2.1  Q: 2.4  R: 3.5
   
   In which of the following diatomic molecules would the least polar bond be expected?

   A. LM
   B. MQ
   C. QR
   D. LR
   E. MR

10. Which bond in the following molecule is the most polar?

   
   A. C—H
   B. C—Cl
   C. C—Br
   D. C—O
   E. C—F

11. Identify which of the following bonds is(are) polar and which element in each is the more electronegative.

   HCl  NO  Si₂

   Now consider these five statements about your conclusions.

   1. HCl is polar, with H the more electronegative.
   2. HCl is polar, with the Cl the more electronegative.
   3. NO is polar, with the N the more electronegative.
   4. NO is polar, with O the more electronegative.
   5. Si₂ is polar.

   The correct statement(s) above is(are)

   A. 2 only
   B. 2 and 3 only
   C. 2 and 4 only
   D. 2, 3 and 5 only
   E. 1 and 4 only

12. Which of the following Lewis structures are incorrect?

   
   I
   
   II
   
   III.

   A. I only
   B. II only
   C. III only
   D. I and II
   E. I, II and III

13. Draw a Lewis structure for SO₂Cl⁺ (sulfur is the central atom)

   There are 3 possible structures. Use formal charge to choose the “best” structure.
14. Arrange the following molecules and ions in order of increasing S–O bond strength, starting with the weakest.

I. SO
II. SO$_2$
III. SO$_3^{2-}$

15. Which one of the following pairs of Lewis structures represents resonance?

A.

\[
\begin{array}{l}
\text{B.} \\
\text{C.}
\end{array}
\]

16. Which of the following violates the octet rule?

i. KCl     ii. SiF$_4$     iii. ICl$_4^-$

17. Read the following statements:

1. BF$_3$ and PF$_5$ are examples of violations of the octet rule.
2. BF$_4^-$ and BF$_3$–NH$_3$ are examples of violations of the octet rule.
3. Expanded valence shells occur most often when the central atom is bonded to a small, electronegative element.
4. The central atoms most capable of having expanded valence shells come from rows 3, 4, and 5 of the periodic table.

A. Only statements 1, 3, and 4 are correct.
B. Only statements 1 and 4 are correct.
C. Only statements 2, 3, and 4 are correct.
D. Only statements 3 and 4 are correct.
E. Only statements 2 and 4 are correct.

18. Which of the following species violates the octet rule?

A. GeF$_4$
B. TeF$_4$
C. BH$_4^-$
D. SO$_4^{2-}$
E. SiH$_4$
1. Which of the following contains both ionic and covalent bonds?
   i. HBr
   ii. Na₂CO₃
   iii. KCl
   iv. LiOH

2. How many valence electrons are in the ion BrO₃⁻? Draw the Lewis structure for BrO₃⁻.

3. The skeletal structure of N,N dimethylformamide is shown to the right. How many lone pairs and how many double bonds are in the molecule when a correct Lewis structure is drawn?

4. E is an unknown element in the Lewis structure shown to the right. Which one of the following elements could be the correct identity for E?
   A. C  D. O
   B. N  E. Xe
   C. F

5. The cyanate ion (NCO⁻) has several possible Lewis structures. Which of the following is the best Lewis structure?
   \[
   \text{A. } \begin{array}{c}
   \text{N} \\
   \text{C} \\
   \text{O}
   \end{array}
   \]
   \[
   \text{B. } \begin{array}{c}
   \text{N} \\
   \text{C} \\
   \text{O}
   \end{array}
   \]
   \[
   \text{C. } \begin{array}{c}
   \text{N} \\
   \text{C} \\
   \text{O}
   \end{array}
   \]
   \[
   \text{D. } \begin{array}{c}
   \text{N} \\
   \text{C} \\
   \text{O}
   \end{array}
   \]
   \[
   \text{E. } \begin{array}{c}
   \text{N} \\
   \text{C} \\
   \text{O}
   \end{array}
   \]
6. Arrange the following molecules and ions are in order of increasing N–O bond strength, starting with the weakest.

   I.  NO$^-$
   II. NO$_2^-$
   III. NO$_3^-$

7. Which of the following violates the octet rule?

   i.  MgO
   ii  I$_3^-$
   iii ClO$_2^-$

8. Which of the following pairs of Lewis diagrams is a correct pair of resonance structures?

   i.  
   
   ii. 
   
   iii. 

9. Each of these molecules or ions has a C–N bond. Order each of these species with respect to the C – N bond length (Shortest to longest.).

   1. OCN$^-$  2. CH$_3$NH$_2$  3. SCN$^-$  4. 

   ![Image of a molecule]