

TOPIC 4 PROBLEM SET – BONDING

Ionic Bonding

1. An ionic bond is characterized as the _____ of electrons between an element with _____ electronegativity and an element with _____ electronegativity (typically a metallic element and a nonmetallic element).
2. An element has 19 protons. What will be the charge of ions it forms?
3. What will be the charge of the ions formed by an element with an electron structure of $1s^2 2s^2 2p^6 3s^2 3p^5$?
4. Valence electrons are only found in the _____ and _____ sublevels, not in the _____ or _____.
5. The table below shows the electron structures for 5 pairs of elements. Predict the compound that will form. The first one is completed as an example.

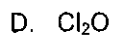
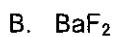
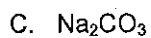
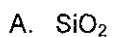
Element A	Element B	Formula
$1s^2 2s^2 2p^6 3s^2$	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^5$	AB_2
$1s^2 2s^1$	$1s^2 2s^2 2p^5$	
$1s^2 2s^2 2p^1$	$1s^2 2s^2 2p^6 3s^2 3p^4$	
$1s^2 2s^2 2p^6 3s^1$	$1s^2 2s^2 2p^4$	

6. Describe the crystal structure that occurs in solid ionic compounds, and why this is not considered a molecular solid.

Covalent Bonding

7. Covalent bonding is defined as the _____ of electrons between an element with _____ electronegativity and another element with _____ electronegativity (typically two nonmetallic elements).
8. An element forms a covalently bonded compound with hydrogen, and has the formula XH_4 . In which group of the periodic table would X be found? What is the name of this group?
9. Two atoms each provide 3 electrons that are shared by the two atoms. This is an example of a :
 - A. single covalent bond
 - B. double covalent bond
 - C. triple covalent bond
 - D. quadruple covalent bond
10. Two atoms each provide 1 electron that are shared by the two atoms. This is an example of a :
 - A. single covalent bond
 - B. double covalent bond
 - C. triple covalent bond
 - D. quadruple covalent bond
11. A certain nonmetal usually forms two covalent bonds in its compounds. How many valence electrons does this element have?
12. Noble gases do not form chemical compounds because:

13. Which of the following compounds contains ionic and covalent bonds?



14. Predict the number of covalent bonds that would form and then predict a formula for:

a. nitrogen and chlorine

b. chlorine and hydrogen

c. silicon and fluorine

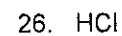
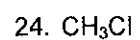
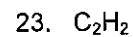
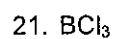
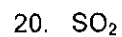
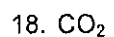
Shapes of Molecules

a) Draw a Lewis structure

b) Predict the orbital geometry and molecular geometry

c) Give the bond angles

d) tell whether the molecule is polar or nonpolar:



28. A molecule that has a tetrahedral shape would have _____ nonbonding or "lone" pairs of electrons.
29. A molecule that has a trigonal pyramidal shape would have _____ nonbonding or "lone" pairs of electrons.
30. Carbon and chlorine form a series of compounds: CH_4 , CH_3Cl , CH_2Cl_2 , CHCl_3 , CCl_4 . Which of these will be polar molecules?
- A. CCl_4 only
B. CH_3Cl and CH_2Cl_2 only
C. CH_3Cl , CH_2Cl_2 , and CHCl_3 only
D. CH_3Cl , CHCl_3 , CH_2Cl_2 , and CCl_4 only
31. For each of the following pairs, which atom (if any) in the following bonds carries a partial negative charge?
- a. $\text{H}\text{---}\text{H}$
b. $\text{O}\text{---}\text{P}$
c. $\text{C}\text{---}\text{F}$
d. $\text{S}\text{---}\text{S}$
e. $\text{B}\text{---}\text{O}$
32. The proper Lewis structure for the NO_3^- ion contains resonance structures. What is the purpose of showing resonance structures?
33. What is the N-O bond order in NO_3^- ? Explain.
34. Which would have the longest N-O bond, NO_2^- or NO_3^- ? Explain.
35. Draw a Lewis structure for C_2F_4 .

Sketch a bonding diagram of the molecule (including 3-dimensional representations of the bonding orbitals). Label σ and π bonds.

36. Consider C₂H₆ (ethane) and C₂H₄ (ethene).

a) Draw a Lewis diagram for each.

b) Count the total number of sigma and pi bonds in each:

C₂H₆: σ _____ π _____ C₂H₄: σ _____ π _____

c) Describe the formation of sigma and pi bonds.

d) Compare the C – H bond angles in each.

e) Compare the carbon-carbon bond order, bond length, and bond strength in each.

37. Complete the chart:

Formula	Lewis Structure	Hybridization of Central atom	Orbital geometry	3- D picture with polarity vectors	molecular geometry	polar?
SiF ₄						
BrF ₅						
ClF ₃						
NO ₂ ⁻						
NO ₃ ⁻						
SBr ₄						

Formula	Lewis Structure	Hybrid. of Central atom	Orbital geometry	3- D picture with polarity vectors	Molecular geometry	Polar?
CN						
XeF ₄						
BF ₃						
OF ₂						
CO ₃ ²⁻						
PF ₅						
PI ₃						
SF ₆						
XeF ₂						
CS ₂						

48. Classify these substances as ionic, molecular, network, or metallic solids:
- structure composed of atoms covalently bonded to neighboring atoms
 - a solid only at extremely low temperatures
 - a good conductor of heat and electricity
 - a good electric conductor only in solution
49. Which of the following substances would be soluble in water?
- | | |
|--|--|
| A. $\text{CH}_3\text{-CH}_2\text{-CH}_2\text{-CH}_2\text{-CH}_2\text{-CH}_2\text{-CH}_3$ | C. $\text{Cl-CH}_2\text{-CH}_2\text{-CH}_2\text{-CH}_2\text{-Cl}$ |
| B. $\text{H}_2\text{N-CH}_2\text{-CH}_2\text{-CH}_2\text{-CH}_2\text{-NH}_2$ | D. $\text{CH}_3\text{-CH}_2\text{-CH}_2\text{-O-CH}_2\text{-CH}_2\text{-CH}_2\text{-CH}_3$ |
50. When ethanol ($\text{C}_2\text{H}_5\text{OH}$) boils, the gas consists of
- | | |
|--|----------------------|
| A. a mixture of carbon dioxide and water | C. water and ethanol |
| B. carbon, hydrogen, and oxygen | D. ethanol only |
51. Elements A, B, C, and D have consecutive atomic numbers. Element D is a monatomic gas with low melting and boiling points. All efforts to form compounds of D in the laboratory have failed.
- Which of the remaining elements, A, B, or C has the strongest affinity for an additional electron?
 - A compound of an alkali metal M with element C has a formula of MC. Does this compound have ionic or covalent bonds? Predict other properties of MC such as melting point and solubility in water.
 - Write the formulas for hydrides of elements A, B, and C.
 - Predict the shape of each hydride molecule from above.
 - Predict the conductivity of solid B.
52. For each of the following liquids, list the type of intermolecular forces you would expect to find.
- water, H_2O
 - bromine, Br_2
 - carbon tetrachloride, CCl_4

53. Explain the reasons for the difference in boiling points between

HF (20 C) and HCl (-85 C)

HCl (-85 C) and LiCl (1360 C)

CH₂CH₂CH₂OH (78.4 C) and CH₂CH₂CH₂CH₂CH₂CH₂OH (157 C)

54. Match each of the solids in the first column with two properties in the second column. Try to use each property at least once.

a. metallic solid

b. covalent network solid

c. ionic solid

d. molecular solid

I. low melting point

II. high melting point

III. conducts electricity in solution

IV. brittle

V. hard

VI. malleable

55. Describe and compare the structure and bonding present in the three allotropes of carbon (diamond, graphite, and C₆₀ fullerene).

For each of the following pairs in 54 – 60, circle the compound that would have the higher boiling point. Briefly explain.

56. RbF or NaF

57. CH₃-CH₂-CH₂-CH₂-CH₂-CH₃ or CH₃-C(CH₃)₂-CH₂-CH₃

58. Mg or Na

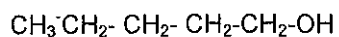
59. PCl₃ or MgCl₂

60. I₂ or Cl₂

61. CH₃-CH₂-OH or CH₃-O-CH₃

62. H₂O or H₂S

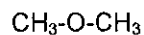
63. Circle the formula of the compound that would be more soluble in water. Explain.



or



or



64. _____ substances are malleable and conduct electricity

A. metallic

B. ionic

C. network covalent

D. molecular covalent

65. _____ substances have low boiling points and do not conduct electricity in any state

A. metallic

B. ionic

C. network covalent

D. molecular covalent

66. _____ substances have high melting points and do not conduct electricity in any state

A. metallic

B. ionic

C. network covalent

D. molecular covalent

67. _____ substances have high melting points and conduct electricity in liquid (not solid) state

A. metallic

B. ionic

C. network covalent

D. molecular covalent

68. Compare the three allotropes of carbon in terms of the hybridization of the carbon atoms, the molecular geometry around the carbon atoms, their electrical conductivities, and their hardness. Describe the 3-dimensional structure shown by each of these allotropes. Identify the allotrope of carbon that is most like silicon dioxide.