1. Which of the following statements contrasting covalent bonds and ionic bonds is correct?
   A) Covalent bonds usually involve two nonmetals and ionic bonds usually involve two metals.
   B) Covalent bonds usually involve two metals and ionic bonds usually involve a metal and a nonmetal.
   C) Covalent bonds usually involve a metal and a nonmetal and ionic bonds usually involve two nonmetals.
   D) Covalent bonds usually involve two nonmetals and ionic bonds usually involve a metal and a nonmetal.

2. Which of the following molecular compounds would have a Lewis structure that contains 10 electron dots?
   A) HCN
   B) H₂O
   C) NH₃
   D) CO₂

3. In which of the following molecular compounds are all the bonds single bonds?
   A) CS₂
   B) CSe
   C) PCl₃
   D) O₂

4. The total number of nonbonding electron pairs present in the Lewis structure of GeH₄ is
   A) zero
   B) one
   C) two
   D) four

5. Which of the following statements concerning double covalent bonds is correct?
   A) they are found only in molecules that contain P or N
   B) they are only found in molecules that contain at least two different kinds of atoms
   C) they occur only between atoms containing 2 valence electrons
   D) they always involve the sharing of 4 electrons
6. Which of the following statements concerning coordinate covalent bonds is correct?
   A) One of the atoms involved must be a metal and the other a nonmetal.
   B) Both atoms involved in the bond contribute three electrons to the bond.
   C) Once formed, they are indistinguishable from any other covalent bond.
   D) They occur only in molecules where all bonds are single bonds.

7. In which of the following molecules is a coordinate covalent bond present?
   A) H – C \equiv N
   B) O = C = O
   C) N \equiv N
   D) N \equiv N – O

8. The Lewis structure for the polyatomic ion NO_2^+ contains
   A) 2 double bonds and 8 nonbonding electrons.
   B) 1 double bond, 1 single bond, and 12 nonbonding electrons.
   C) 2 single bonds and 12 nonbonding electrons.
   D) 2 triple bonds and 4 nonbonding electrons.

9. For which of the following pairs of elements would the compound formed between them most likely be a molecular compound?
   A) Na and I
   B) Ti and O
   C) Si and Br
   D) Ba and F

10. Which of the following compounds contains both ionic and covalent bonds?
    A) SO_2
    B) NaBr
    C) LiCN
    D) NF_3

11. VSEPR theory predicts that the geometry of the PCl_3 molecule is
    A) linear
    B) trigonal planar
    C) trigonal pyramidal
    D) tetrahedral
12. What is the geometry of the molecular compound formed by the reaction of sulfur with hydrogen?
   A) linear
   B) angular
   C) trigonal planar
   D) tetrahedral

13. Which of the following sets of elements is arranged in order of decreasing electronegativity?
   A) F, Br, As
   B) Cl, Al, O
   C) Br, O, As
   D) Li, Si, O

14. Electronegativity is a concept that is useful along with other concepts in
   A) predicting the polarity of a bond.
   B) deciding how many electrons are involved in a bond.
   C) formulating a statement of the octet rule.
   D) determining the charge on a polyatomic ion.

15. In which of the following bonds is the bond polarity incorrect?
   A) H—F
   B) K—O
   C) Mg—H
   D) Cl—I

16. Given the following electronegativites: Li = 1.0, H = 2.1, F = 4.0 which of the following statements is true?
   A) H₂, F₂, and HF are nonpolar covalent molecules
   B) LiF is a nonpolar covalent compound and HF is an ionic compound
   C) HF is a nonpolar covalent compound and F₂ is a polar covalent molecule
   D) F₂ is a nonpolar covalent molecule and HF is a polar covalent molecule
17. Which of the following diatomic molecules contains the bond of greatest polarity?
   A) $\text{B}_2$
   B) $\text{Cl}_2$
   C) $\text{ClF}$
   D) $\text{BrF}$

18. Which of the following linear molecules is a nonpolar molecule containing polar bonds?
   A) $\text{H} - \text{C} \equiv \text{N}$
   B) $\text{O} = \text{C} = \text{O}$
   C) $\text{H} - \text{Cl}$
   D) $\text{N} \equiv \text{N}$

19. Which of the following is a molecular compound that contains 5 atoms per molecule?
   A) germanium tetrabromide
   B) ditellerium monoxide
   C) diarsenic pentaselenide
   D) silicon dioxide

20. The correct name for the compound $\text{H}_2\text{Te}$ is
   A) hydrogen telluride
   B) dihydrogen telluride
   C) dihydrogen monotelluride
   D) hydrogen monotelluride

21. Which of the following statements concerning differences between ionic and molecular compounds is correct?
   A) Molecular compounds contain two elements, and ionic compounds contain three or more elements.
   B) Ionic compounds contain oxygen, and molecular compounds do not.
   C) Molecular compounds possess a molecular structural unit, and ionic compounds do not.
   D) more than one correct response
   E) no correct response

22. In which of the following pairs of compounds are both members of the pair molecular compounds?
   A) $\text{PCl}_3$ and $\text{LiBr}$
   B) $\text{CCl}_4$ and $\text{KOH}$
   C) $\text{NaH}$ and $\text{CaF}_2$
   D) more than one correct response
   E) no correct response
23. Sixteen electrons are present in the Lewis structure of which of the following molecules?
   A) CO₂
   B) N₂O
   C) SO₂
   D) more than one correct response
   E) no correct response

24. The number of nonbonding electrons exceeds the number of bonding electrons in the Lewis structure of which of the following molecules?
   A) HCN
   B) NH₃
   C) H₂O
   D) more than one correct response
   E) no correct response

25. In which of the following triatomic molecules or ions are both of the bonds multiple bonds?
   A) HCN
   B) CO₂
   C) NO₂⁻
   D) more than one correct response
   E) no correct response

26. Coordinate covalent bonds differ from normal covalent bonds in that
   A) one atom supplies more electrons to the bond than the other atom.
   B) the electrons of the bond move about in a coordinated pattern.
   C) atoms involved must always also possess nonbonding electron pairs.
   D) more than one correct response
   E) no correct response

27. An angular geometry is associated with molecules in which the central atom has
   A) two bonds and two nonbonding electron groups.
   B) two bonds and one nonbonding electron group.
   C) two bonds and no nonbonding electron groups.
   D) more than one correct response
   E) no correct response
28. In which of the following pairs of triatomic species do both members of the pair have the same geometry?
   A) H₂O and H₂S
   B) NO₂⁺ and NO₂⁻
   C) HCN and FNO
   D) more than one correct response
   E) no correct response

29. In which of the following pairs of bonds is the first listed bond more polar than the second listed bond?
   A) N–N and N–F
   B) P–Cl and S–Cl
   C) C–N and C–F
   D) more than one correct response
   E) no correct response

30. If the electronegativity difference between two atoms X and Z is 1.0, the bond between the two atoms would be
   A) ionic.
   B) polar covalent.
   C) coordinate covalent.
   D) more than one correct response
   E) no correct response

31. Which of the following statements concerning molecular polarity is correct?
   A) All diatomic molecules are polar.
   B) All linear triatomic molecules are nonpolar.
   C) Triatomic molecules in which all bonds are polar must be polar.
   D) more than one correct response
   E) no correct response

32. Which of the following tetrahedral molecules is polar?
   A) CH₄
   B) CF₄
   C) CH₃F
   D) more than one correct response
   E) no correct response
33. A period 2 nonmetal, X, forms the molecular compound NX₃. Which of the following are also correct formulas for molecular compounds involving X?
A) HX
B) OX₂
C) C₂X
D) more than one correct response
E) no correct response

34. For which of the following pairs of compounds do both members of the pair have names that contain the prefix di-?
A) SCl₂ and K₂O
B) CO₂ and N₂O
C) N₂O₃ and H₂S
D) more than one correct response
E) no correct response

35. For which of the following pairs of molecular compounds do both members of the pair contain the same number of atoms per molecule?
A) hydrogen peroxide and ammonia
B) hydrazine and methane
C) phosphine and ethane
D) more than one correct response
E) no correct response

Use the following to answer questions 36-45:

In each of the following multiple-choice questions, characterize EACH of the three given statements as being TRUE or FALSE and then indicate the collective true-false status of the statements using the choices
a) All three statements are true.
b) Two of the three statements are true.
c) Only one of the statements is true.
d) None of the statements is true.
36. Statements:
(1) Nonbonding electron pairs are present on both the H and the F in the molecule HF.
(2) The two atoms involved in a multiple covalent bond must always be atoms of the same element.
(3) A molecule of hydrogen peroxide contains more atoms than does a molecule of ammonia.
A) All three statements are true.
B) Two of the three statements are true.
C) Only one of the statements is true.
D) None of the statements is true.

37. Statements:
(1) Once a coordinate covalent bond is formed, there is no way to distinguish it from any of the other covalent bonds in a molecule.
(2) The least electronegative elements are located to the far right in the periodic table.
(3) The central concept of VSEPR theory is that the electron groups in the valence shell of a central atom in a molecule attract each other.
A) All three statements are true.
B) Two of the three statements are true.
C) Only one of the statements is true.
D) None of the statements is true.

38. Statements:
(1) A nitrogen-oxygen bond is more polar than a nitrogen-fluorine bond.
(2) There are no nonbonding electron pairs present on the central atom in a trigonal planar molecule.
(3) The “normal” number of covalent bonds that the element carbon forms is four.
A) All three statements are true.
B) Two of the three statements are true.
C) Only one of the statements is true.
D) None of the statements is true.

39. Statements:
(1) The predicted formula of the simplest molecular compound formed between nitrogen and fluorine is NF₂.
(2) The majority of compounds contain covalent bonds rather than ionic bonds.
(3) In VSEPR theory, double bonds exert double the influence of single bonds in determining molecular geometry.
A) All three statements are true.
B) Two of the three statements are true.
C) Only one of the statements is true.
D) None of the statements is true.
40. Statements:
   (1) The number of “electron dots” in the Lewis formula for the compound HNO₃ is 24.
   (2) Atoms participating in coordinate covalent bonds generally do not form the
       “normal” number of covalent bonds expected for that element.
   (3) Some molecules are nonpolar even though all bonds within the molecules are polar.
       A) All three statements are true.
       B) Two of the three statements are true.
       C) Only one of the statements is true.
       D) None of the statements is true.

41. Statements:
   (1) In the molecule N₂ there are more bonding electron pairs than nonbonding electron
       pairs.
   (2) Electronegativity values for sequential period 2 elements differ by 0.5 units.
   (3) The octet rule does not apply to covalent compounds in which coordinate covalent
       bonding is present.
       A) All three statements are true.
       B) Two of the three statements are true.
       C) Only one of the statements is true.
       D) None of the statements is true.

42. Statements:
   (1) Both tetrahedral and trigonal pyramidal molecules have four VSEPR electron groups
       about the central atom.
   (2) The greater the electronegativity difference between two bonded atoms the greater
       the polarity of the bond between the two atoms.
   (3) A double covalent bond between two atoms is approximately twice as strong as a
       single covalent bond between the same two atoms.
       A) All three statements are true.
       B) Two of the three statements are true.
       C) Only one of the statements is true.
       D) None of the statements is true.

43. Statements:
   (1) In the molecule SO₂ both a single bond and a double bond are present.
   (2) A linear symmetrical triatomic molecule will always be nonpolar.
   (3) The total number of valence electrons available for bonding in the polyatomic ion
       PO₄³⁻ is 30.
       A) All three statements are true.
       B) Two of the three statements are true.
       C) Only one of the statements is true.
       D) None of the statements is true.
44. Statements:
(1) A pentaatomic tetrahedral molecule may be polar or nonpolar depending on the identities of the atoms present.
(2) A bond between atoms which differ in electronegativity by 2.1 units is classified as a polar covalent bond.
(3) The sum of the number of valence electrons a nonmetallic atom has and the number of covalent bonds it “normally” forms is eight.
A) All three statements are true.
B) Two of the three statements are true.
C) Only one of the statements is true.
D) None of the statements is true.

45. Statements:
(1) Nitric oxide, a molecule with two unpaired electrons, is an important chemical in the human body.
(2) The molecular carbon monoxide serves as a precursor for the formation of both acid rain and smog.
(3) An important factor in determining whether a substance has an odor is molecular geometry.
A) All three statements are true.
B) Two of the three statements are true.
C) Only one of the statements is true.
D) None of the statements is true.

Use the following to answer questions 46-50:

For each of the bonding characteristics, select from the response the correct number of electrons that are involved. Responses on the right may be used more than once or need not be used at all.

a) zero
b) one
c) four
d) eight

46. Number of electrons in the Lewis structure for NH₃

47. Number of shared electrons in the Lewis structure for H₂O

48. Number of double bonds in the Lewis structure for CH₄

49. Number of nonbonding electrons in the Lewis structure for CN⁻ ion
50. Number of shared electrons contributed by oxygen to the coordinate covalent bond in CO

Use the following to answer questions 51-55:

Characterize the bond that forms between each set of atoms, using the response. The number associated with each of the atoms is its electronegativity. Responses on the right may be used more than once or need not be used at all.

a) polar covalent bond
b) nonpolar covalent bond
c) coordinate covalent bond
d) ionic bond

51. C (2.5) and H (2.1)
52. N (3.0) and F (4.0)
53. Li (1.0) and O (3.5)
54. N (3.0) and Cl (3.0)
55. Be (1.5) and C (2.5)

Use the following to answer questions 56-60:

For each of the compound characterizations, select from the response the appropriate Lewis structure. Responses on the right may be used more than once or need not be used at all.

a) \( \overset{\cdot}{O} \equiv \overset{\cdot}{H} \)

b) \( :N\equiv N\equiv \overset{\cdot}{O} : \)

c) \( \overset{\cdot}{H} \equiv \overset{\cdot}{P} \equiv \overset{\cdot}{H} \)

\[ \begin{array}{c}
\text{H} \\
\text{H} \\
\text{H}
\end{array} \]

d) \( \overset{\cdot}{H} \equiv \overset{\cdot}{C} \equiv \overset{\cdot}{H} \)

\[ \begin{array}{c}
\text{H} \\
\text{H}
\end{array} \]

56. Compound with a trigonal pyramidal geometry
57. Compound that is nonpolar

58. Compound that has an angular geometry

59. Compound that contains both polar and nonpolar bonds

60. Compound in which the arrangement of electron groups about the central atom is not tetrahedral

Use the following to answer questions 61-65:

A, X, and Z are different elements with different electronegativities. For each of the molecules involving these elements, select a correct characterization from the response. Responses on the right may be used more than once or need not be used at all.

a) polar molecule with polar bonds
b) polar molecule with both polar and nonpolar bonds
c) nonpolar molecule with polar bonds
d) nonpolar molecule with nonpolar bonds

61. Linear A–X–A

62. Linear A–X–Z

63. Linear Z–A–X

64. Linear A–A–X

65. Linear A–A–A
Use the following to answer questions 66-70:

For each of the compounds, select from the response the correct number of atoms present in a molecule of the compound. Responses on the right may be used more than once or need not be used at all.

a) contains 3 or fewer atoms
b) contains 4 atoms
c) contains 5 atoms
d) contains 6 or more atoms

66. Dichlorine monoxide

67. Nitrogen dioxide

68. Hydrogen sulfide

69. Methane

70. Hydrazine
Answer Key

1. D
2. A
3. C
4. A
5. D
6. C
7. D
8. A
9. C
10. C
11. C
12. B
13. A
14. A
15. D
16. D
17. D
18. B
19. A
20. A
21. C
22. E
23. D
24. E
25. B
26. A
27. D
28. A
29. B
30. B
31. E
32. C
33. D
34. B
35. A
36. D
37. C
38. B
39. C
40. A
41. B
42. A
43. B
44. B
45. C
46. d
47. c
48. a
49. c
50. c
51. b
52. a
53. ad
54. ab
55. a
56. c
57. d
58. a
59. b
60. b
61. c
62. a
63. a
64. b
65. d
66. a
67. a
68. a
69. c
70. d