Multiple Choice
Identify the choice that best completes the statement or answers the question.

1. Which response includes only the true statements concerning the characteristics of covalent compounds?
   I. These compounds can be gases, liquids, or solids with low melting points.
   II. Most are soluble in polar solvents.
   III. Liquid and molten compounds do not conduct electricity.
   IV. Aqueous solutions of these compounds are very good conductors of electricity.
   a. I and III
   b. II and IV
   c. I, III, and IV
   d. I, II, and III
   e. IV

2. Which Lewis Dot Formula below is incorrect?
   a. ⋅O⋅
   b. ⋅C⋅
   c. ⋅I⋅
   d. Ca⋅
   e. ⋅Al⋅

3. How many valence electrons does an iodine atom have?
   a. 6
   b. 4
   c. 3
   d. 5
   e. 7

4. How many unpaired electrons are shown in a Lewis Dot Formula for silicon?
   a. 4
   b. 3
   c. 1
   d. 0
   e. 2

5. The negative ion F⁻ has the same electronic configuration as the positive ion ____.
   a. K⁺
   b. Li⁺
   c. Ca²⁺
   d. Mg²⁺
   e. Sc³⁺
6. Calcium and chlorine react to form CaCl₂, an ionic compound. The chloride ion, Cl⁻, has ____ electrons in its outermost occupied shell.
   a. 6  b. 2  c. 7  d. 18  e. 8

7. Which of the following compounds has the most ionic bond?
   a. NF₃  b. NaF  c. NF₃  d. MgF₂  e. BCl₃

8. When one mole of calcium, Ca, combines with one-half mole of oxygen, O₂, to form calcium oxide, CaO, ____ mole(s) of electrons are transferred from ____ atoms to ____ atoms.
   a. two; calcium; oxygen  b. one; oxygen; calcium  c. two; oxygen; calcium  d. one; calcium; oxygen  e. one-half; oxygen; calcium

9. Consider the formation of one formula unit of AlF₃ from neutral atoms. In the process, each aluminum atom ____ electron(s) and each fluorine atom ____ electron(s).
   a. gains one; loses three  b. loses three; gains one  c. loses three; gains three  d. gains three; loses one  e. loses one; gains three

10. What is the formula for the binary compound of calcium and bromine?
    a. CaB  b. CaBr₂  c. Ca₂Br  d. CaB₂  e. CaBr

11. The formula for the simple ionic compound of barium and nitrogen is ____.

12. Which one of the formulas below is incorrect?
    a. Cs₂S  b. AlP  c. CaSe₂  d. SrCl₂
13. A chemical bond formed by two atoms sharing one or more pairs of electrons is called a(n) ____ bond.
   a. polar
   b. ionic
   c. nonpolar
   d. coordinate covalent
   e. covalent

14. When the diatomic molecule H₂ forms, all of the following are true except:
   a. The 1s orbitals overlap so that both electrons are now in the orbitals of both atoms.
   b. The bonded atoms are at higher energy than the separated atoms.
   c. A pair of electrons is shared between the two hydrogen atoms.
   d. A single covalent bond is formed.
   e. Each hydrogen atom has the helium configuration 1s².

15. The ____ bonds there are between atoms of the same two elements, the ____ the bond length and the ____ the bond.
   a. fewer; greater; stronger
   b. more; shorter; weaker
   c. more; shorter; stronger
   d. fewer; shorter; stronger
   e. more; greater; weaker

16. Draw the Lewis dot formula for PCl₃. The number of unshared pairs of electrons in the outer shell of the central atom is ____.
   a. two
   b. four
   c. one
   d. zero
   e. three

17. The number of unshared pairs of electrons in the outer shell of sulfur in H₂S is ____.
   a. two
   b. four
   c. one
   d. zero
   e. three

18. In applying the relationship S = N - A for the PF₃ molecule N = ____, A = ____., and S = ____.
   a. 34          26          8
   b. 32          24          8
   c. 30          22          8
   d. 30          24          6
   e. 32          26          6

19. In constructing the dot formula for H₃AsO₄, N = ____, A = ____., and S = ____.
   N     A     S
   a. 43   28   8
   b. 41   26   8
   c. 39   24   6
   d. 39   26   6
   e. 41   28   8
20. The number of unshared pairs of electrons in the outer shell of oxygen in Cl\textsubscript{2}O is ____.
   a. four
   b. zero
   c. one
   d. two
   e. three

21. Draw the dot formula for ethylene, C\textsubscript{2}H\textsubscript{4}. Each carbon–hydrogen bond is a ____ bond and each carbon–carbon bond is a ____ bond.
   a. double; single
   b. double; double
   c. single; triple
   d. single; single
   e. single; double

22. The Lewis dot formula for N\textsubscript{2} shows
   a. a triple covalent bond.
   b. a total of 8 × 2 = 16 electrons.
   c. a single ionic bond.
   d. a double covalent bond.
   e. a single covalent bond.

23. Which of the following guidelines for drawing Lewis formulas for covalent compounds is incorrect?
   a. Representative elements (except hydrogen) usually follow the octet rule.
   b. Hydrogen can never be a central atom.
   c. In neutral species, nitrogen forms 3 bonds and oxygen forms 2 bonds.
   d. Carbon always forms 4 bonds.
   e. One carbon atom in a compound may form both a double bond and a triple bond.

24. Assign a formal charge to each atom of

   \[
   :\text{Cl} : \text{As} : \text{Cl} : \\
   :\text{Cl} :
   \]

   a. As = 3+; Cl = 1–
   b. As = 5–; Cl = 7+
   c. As = 6+; Cl = 2–
   d. As = 0; Cl = 0
   e. As = 5+; Cl = 1–

25. Assign a formal charge to each atom of PH\textsubscript{4}⁺.
   a. P = 0; H = \(\frac{1}{4}\)+
26. Which of the following statements about Lewis structures is false?
   a. Quadruple bonds are not possible.
   b. N, P and As can sometimes share more than 8 e⁻.
   c. H can never make more than one bond.
   d. Carbon and oxygen may form a double bond.
   e. Any Noble gas involved in a bond must be violating the octet rule.

27. Which one of the following dot formulas is incorrect?
   a. C₂H₄, \( \text{C : C} \)
   b. \( \text{F : F : Si : F} \)
   c. PH₃, \( \text{H : P : H} \)
   d. BCl₃, \( \text{H : Cl : Cl} \)
   e. \( \text{SO}_3^{2-}, \left[ \text{O : S : O} \right]^{2-} \)

28. Which response lists all of the correct Lewis dot formulas and no incorrect ones?
   I. \( \text{H : O : P : O} \), \( \text{H}_3\text{PO}_4 \)
   II. \( \text{F : As : F : F} \), \( \text{AsF}_5 \)
   III. \( \text{I : Be : I} \), \( \text{BeI}_2 \)
   IV. \( \text{F : C : F} \), \( \text{CF}_4 \)
29. How many lone pairs of electrons are there on the S atom in the SCl₄ molecule?
   a. three
   b. zero
   c. one
   d. two
   e. four

30. Which response lists all the molecules below that have one unshared pair of electrons on the central atom, and no other molecules?
   H₂O, NF₃, BF₃, OF₂
   a. NF₃ and OF₂
   b. H₂O, NF₃, and OF₂
   c. H₂O and NF₃
   d. H₂O
   e. NF₃

31. Which one of the following molecules violates the octet rule?
   a. OF₂
   b. PCl₃
   c. AsF₃
   d. CBr₄
   e. NF₃

32. Which response contains all the molecules below that violate the octet rule, and no others?
   SF₄, SiCl₄, H₂Te, AsF₅, BeI₂
   a. H₂Te, BeI₂
   b. SF₄, AsF₅, BeI₂
   c. SF₄, SiCl₄
   d. AsF₅
   e. BeI₂

33. Which numbered response lists all the molecules below that exhibit resonance and none that do not?
   I. PF₅
   II. HNO₃
   III. SO₂
   IV. H₂O
   a. I and II
   b. II and III
   c. III and IV
   d. I and III
34. How many resonance structures does the nitrate ion, $\text{NO}_3^-$, have?
   a. 1
   b. 4
   c. 0
   d. 3
   e. 2

35. How many resonance structures does the bicarbonate ion, $\text{HCO}_3^-$, have?
   a. 3
   b. 1
   c. 2
   d. 4
   e. 0

36. Which response includes all of the molecules that have nonpolar bonds, and no others?
   Cl$_2$, BeCl$_2$, I$_2$, BrCl, BCl$_3$
   a. Cl$_2$, BeCl$_2$, and I$_2$
   b. Cl$_2$, BeCl$_2$, and BrCl
   c. BrCl
   d. Cl$_2$ and I$_2$
   e. BeCl$_2$ and BCl$_3$

37. Which molecule contains the least polar bonds? (Electronegativities: H = 2.1, C = 2.5, F = 4.0, Cl = 3.0, Br = 2.8, I = 2.5)
   a. Cl$_4$
   b. CBr$_4$
   c. CCl$_4$
   d. CF$_4$
   e. CH$_4$

38. Which of the following molecules has the least polar bonds?
   a. HF
   b. NH$_3$
   c. HI
   d. BrI
   e. H$_2$O

39. Which one of the following molecules has a dipole moment?
   a. H$_2$
   b. Cl$_2$
   c. I$_2$
   d. N$_2$
   e. BrCl

40. Which molecule would have the strongest dipole moment?
   a. HI
   b. HF
   c. H$_2$
41. Which one of the following compounds involves both ionic and covalent bonding?
   a. HCN
   b. Na₂SO₄
   c. Cl₂
   d. KCl
   e. HF

42. Which one of the following compounds contains both ionic and covalent bonding?
   a. MgO
   b. KNO₃
   c. HCl
   d. Rb₃N
   e. CaCl₂

43. Which of the following is the Lewis dot structure for the potassium ion?
   a. \[ \begin{array}{c}
   \cdot \\
   \text{K} \\
   \cdot \\
   \end{array} \]
   b. \[ \begin{array}{c}
   \cdot \\
   \text{K} \\
   \cdot \\
   \end{array} \]^2+
   c. \[ \begin{array}{c}
   \cdot \\
   \text{K} \\
   \cdot \\
   \end{array} \]^-2
   d. \[ \begin{array}{c}
   \cdot \\
   \text{K} \\
   \cdot \\
   \end{array} \]^+
   e. \[ \begin{array}{c}
   \cdot \\
   \text{K} \\
   \cdot \\
   \end{array} \]^+

44. How many valence electrons does a chlorine atom have?
   a. 8
   b. 1
   c. 7
   d. 4
   e. 3

45. How many unpaired electrons are shown in the Lewis dot formula of an aluminum atom?
   a. 2
   b. 3
   c. 5
   d. 0
46. How many valence electrons are present in the Lewis dot formula of the chlorate ion, ClO₃⁻?
   a. 32  
   b. 26  
   c. 30  
   d. 28  
   e. 24

47. What is the formal charge of N?
   a. -1  
   b. 0   
   c. +1  
   d. -2  
   e. +2

48. The Lewis structure of which of the following formula violates the octet rule?
   a. PF₃  
   b. HF   
   c. SiF₄  
   d. OF₂  
   e. ClF₃

49. When you draw a Lewis structure for CH₃OCH₂CH₃, what is the total number of lone pair electrons?
   a. 3   
   b. 1   
   c. 4   
   d. 2   
   e. 0

50. Based on the Lewis structure for SiF₅⁻ given below, what is the formal charge on the central silicon atom?
   ![Lewis structure of SiF₅⁻]
   a. +1   
   b. -1   
   c. 0    
   d. -2   
   e. +2

51. What is the formal charge on the nitrogen in NO₂Cl?
   a. 0    
   b. -2   
   c. -1   
   d. +2   
   e. +1

52. A molecule will always be polar if it _______.
   a. contains atoms with different electronegativities  
   b. consists of more than three atoms  
   c. is diatomic with different electronegativities  
   d. contains both carbon and chlorine  
   e. has polar bonds
Other

1. Why are $d$ orbital electrons usually not shown in Lewis dot formulas?

2. Why must atomic orbitals overlap to form a covalent bond? What prevents the orbitals from overlapping completely?

3. Why must a compound have at least one double bond to have resonance structures? Why do none of the resonance structures actually represent the real molecule?

4. Suppose on Planet X three electrons can occupy each orbital and there are 4 $p$ orbitals instead of 3. How would this change the "octet" rule?

5. Explain why boron is considered *electron deficient* and how this makes it impossible to complete an octet.

6. Comment on the validity of the following statement: Any noble gas atom involved in a bond must violate the octet rule.

7. How is a formal charge different than a charge on an ion?
Answer Section

MULTIPLE CHOICE

1. ANS: A
   PTS: 1
   OBJ: Identify the chemical and physical properties of covalent compounds.
   TOP: Ionic and Covalent Bonding
   MSC: Conceptual question

2. ANS: B
   PTS: 1
   OBJ: Identify the correct Lewis Dot Formulas.
   TOP: Lewis Dot Formulas of Atoms
   DIF: Harder Question

3. ANS: E
   PTS: 1
   OBJ: Determine the number of valence electrons.
   TOP: Lewis Dot Formulas of Atoms

4. ANS: E
   PTS: 1
   OBJ: Determine the number of unpaired electrons.
   TOP: Lewis Dot Formulas of Atoms

5. ANS: D
   PTS: 1
   OBJ: Identify the isoelectronic ion.
   TOP: Formation of Ionic Compounds

6. ANS: E
   PTS: 1
   OBJ: Determine the number of valence electrons.
   TOP: Formation of Ionic Compounds

7. ANS: B
   PTS: 1
   OBJ: Identify the compound with the greatest ionic character.
   TOP: Formation of Ionic Compounds

8. ANS: A
   PTS: 1
   OBJ: Determine the number of electrons transferred given the balanced reaction.
   TOP: Formation of Ionic Compounds

9. ANS: B
   PTS: 1
   OBJ: Identify the species that lose and gain electrons.
   TOP: Formation of Ionic Compounds

10. ANS: B
    PTS: 1
    OBJ: Identify the formula of a binary compound.
    TOP: Formation of Ionic Compounds

11. ANS: B
    PTS: 1
    OBJ: Identify the formula of a binary compound.
    TOP: Formation of Ionic Compounds

12. ANS: C
    PTS: 1
    OBJ: Identify the incorrect formula of a binary compound.
    TOP: Formation of Ionic Compounds

13. ANS: E
    PTS: 1
    OBJ: Define covalent bond.
    TOP: Formation of Covalent Bonds

14. ANS: B
    PTS: 1
    OBJ: Describe the bonding in hydrogen.
    TOP: Formation of Covalent Bonds

15. ANS: C
    PTS: 1
    OBJ: Understand the relationship between bond order, bond length, and bond strength.
    TOP: Bond Lengths and Bond Energies

16. ANS: C
    PTS: 1
    OBJ: Draw the Lewis structure given the formula and determine the number of unshared outer shell electrons on the central atom.
    TOP: Writing Lewis Formulas: The Octet Rule

17. ANS: A
    PTS: 1
    OBJ: Draw the Lewis structure given the formula and determine the number of unshared outer shell
18. **ANS:** E  **PTS:** 1
   **OBJ:** Determine the number of electrons shared, needed, and available.
   **TOP:** Writing Lewis Formulas: The Octet Rule

19. **ANS:** A  **PTS:** 1
   **OBJ:** Determine the number of electrons shared, needed, and available.
   **TOP:** Writing Lewis Formulas: The Octet Rule

20. **ANS:** D  **PTS:** 1
    **OBJ:** Draw the Lewis structure given the formula and determine the number of unshared outer shell electrons on the central atom.
    **TOP:** Writing Lewis Formulas: The Octet Rule

21. **ANS:** E  **PTS:** 1
    **OBJ:** Draw the Lewis structure given the formula and identify the covalent bonds.
    **TOP:** Writing Lewis Formulas: The Octet Rule

22. **ANS:** A  **PTS:** 1
    **OBJ:** Draw the Lewis structure given the formula and identify the covalent bonds.
    **TOP:** Writing Lewis Formulas: The Octet Rule

23. **ANS:** E  **PTS:** 1
    **OBJ:** Identify the guidelines for drawing valid Lewis Dot Formulas.
    **TOP:** Writing Lewis Formulas: The Octet Rule

24. **ANS:** D  **PTS:** 1
    **OBJ:** Assign formal charges given the Lewis structure.
    **TOP:** Formal Charge

25. **ANS:** C  **PTS:** 1
    **OBJ:** Assign formal charges given the formula.
    **TOP:** Formal Charge

26. **ANS:** B  **PTS:** 1
    **OBJ:** Know the limits and exceptions to the octet rule.
    **TOP:** Writing Lewis Formulas: Limitations of the Octet Rule for Lewis Formulas

27. **ANS:** D  **PTS:** 1
    **OBJ:** Identify the correct Lewis Dot Formulas.
    **TOP:** Writing Lewis Formulas: Limitations of the Octet Rule for Lewis Formulas

28. **ANS:** A  **PTS:** 1
    **OBJ:** Identify the correct Lewis Dot Formulas.
    **TOP:** Writing Lewis Formulas: Limitations of the Octet Rule for Lewis Formulas

29. **ANS:** C  **PTS:** 1
    **OBJ:** Draw the Lewis structure given the formula and determine the number of unshared electrons on the central atom.
    **TOP:** Writing Lewis Formulas: Limitations of the Octet Rule for Lewis Formulas

30. **ANS:** E  **PTS:** 1
    **OBJ:** Draw the Lewis structures given the formulas and determine the number of unshared electrons on the central atoms.
    **TOP:** Writing Lewis Formulas: Limitations of the Octet Rule for Lewis Formulas

31. **ANS:** C  **PTS:** 1
    **OBJ:** Identify the molecule whose Lewis structure violates the octet rule.
    **TOP:** Writing Lewis Formulas: Limitations of the Octet Rule for Lewis Formulas

32. **ANS:** B  **PTS:** 1
    **OBJ:** Identify the molecules with Lewis structures that violate the octet rule.
    **TOP:** Writing Lewis Formulas: Limitations of the Octet Rule for Lewis Formulas

33. **ANS:** B  **PTS:** 1
    **OBJ:** Identify the molecules with more than one valid Lewis structure.
    **TOP:** Resonance

34. **ANS:** D  **PTS:** 1
    **OBJ:** Determine the number of valid Lewis structures given the formula.
    **TOP:** Resonance
35. ANS: C   PTS: 1
   OBJ: Determine the number of valid Lewis structures given the formula.
   TOP: Resonance
36. ANS: D   PTS: 1   OBJ: Identify the molecules with nonpolar covalent bonds
   TOP: Polar and Nonpolar Covalent Bonds
37. ANS: A   PTS: 1   OBJ: Identify the least polar covalent bond.
   TOP: Polar and Nonpolar Covalent Bonds
38. ANS: D   PTS: 1   OBJ: Identify the least polar covalent bond.
   TOP: Polar and Nonpolar Covalent Bonds
39. ANS: E   PTS: 1   OBJ: Identify the molecule with a dipole moment.
   TOP: Dipole Moments
40. ANS: B   PTS: 1   OBJ: Identify the molecule with the largest dipole moment.
   TOP: Dipole Moments
41. ANS: B   PTS: 1   OBJ: Identify the compound with both ionic and covalent bonds.
   TOP: The Continuous Range of Bonding Types
42. ANS: B   PTS: 1   OBJ: Identify the compound with both ionic and covalent bonds.
   TOP: The Continuous Range of Bonding Types
43. ANS: D   PTS: 1   DIF: Easy
   OBJ: Identify the ion Lewis dot formula given ion name.
   TOP: Lewis Dot Formulas of Atoms
   NOT: Dynamic Question
44. ANS: C   PTS: 1   OBJ: Determine the number of valence electrons.
   TOP: Lewis Dot Formulas of Atoms
   NOT: Dynamic Question
45. ANS: E   PTS: 1   OBJ: Determine the number of unpaired valence electrons.
   TOP: Lewis Dot Formulas of Atoms
   NOT: Dynamic Question
46. ANS: B   PTS: 1   OBJ: Determine the total number of valence electrons given the polyatomic ion formula.
   TOP: Lewis Formulas for Molecules and Polyatomic Ions
   NOT: Dynamic Question
47. ANS: B   PTS: 1   OBJ: Determine the formal charge of the specified atom.
   TOP: Lewis Formulas for Molecules and Polyatomic Ions
   NOT: Dynamic Question
48. ANS: E   PTS: 1   OBJ: Determine the formula whose Lewis structure violates the octet rule.
   TOP: Lewis Formulas for Molecules and Polyatomic Ions
   NOT: Dynamic Question
49. ANS: D   PTS: 1   OBJ: Determine the Lewis structure and number of lone pairs of electrons.
   TOP: Lewis Formulas for Molecules and Polyatomic Ions
   NOT: OWL
50. ANS: B   PTS: 1   OBJ: Calculate the formal charge.
    TOP: Formal Charge
    NOT: OWL
51. ANS: E   PTS: 1   OBJ: Calculate the formal charge.
    TOP: Formal Charge
    NOT: OWL
52. ANS: C   PTS: 1   OBJ: Identify molecules that are always polar.
    TOP: Dipole Moments
    NOT: OWL

OTHER

1. ANS:
1. Answer not provided.

PTS: 1
OBJ: Explain the limitations of Lewis formulas with respect to d-orbital electrons.
TOP: Lewis Dot Formulas of Atoms | Lewis Formulas for Molecules and Polyatomic Ions
MSC: Conceptual question

2. Answer not provided.

PTS: 1
OBJ: Explain orbital overlap with respect to bond formation.
TOP: Formation of Covalent Bonds
MSC: Conceptual question

3. Answer not provided.

PTS: 1
OBJ: Explain the limitations of resonance with respect to multiple bonding.
TOP: Resonance
MSC: Conceptual question

4. Answer not provided.

PTS: 1
OBJ: Imagine a world in which the octet rule is not the same as this world.
TOP: Writing Lewis Formulas: The Octet Rule
MSC: Conceptual question

5. Answer not provided.

PTS: 1
OBJ: Explain what is meant by electron deficient and how it affects Lewis structures.
TOP: Writing Lewis Formulas: Limitations of the Octet Rule for Lewis Formulas
MSC: Conceptual question

6. Answer not provided.

PTS: 1
OBJ: Explore the limits of the octet rule in noble gas compounds.
TOP: Writing Lewis Formulas: Limitations of the Octet Rule for Lewis Formulas
MSC: Conceptual question

7. Answer not provided.

PTS: 1
OBJ: Compare and contrast the calculation of formal charge and oxidation state.
TOP: Formal Charge
MSC: Conceptual question