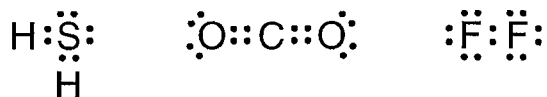


Bonding and Intermolecular Forces

- As two chlorine atoms combine to form a molecule, energy is
 - absorbed
 - released
 - created
 - destroyed
- What is conserved during a chemical reaction?
 - mass, only
 - charge, only
 - both mass and charge
 - neither mass nor charge
- When a chemical bond is broken, energy is
 - absorbed, only
 - released, only
 - both absorbed and released
 - neither absorbed nor released
- In a gaseous system at equilibrium with its surroundings, as molecules of $A(g)$ collide with molecules of $B(g)$ without reacting, the total energy of the gaseous system
 - decreases
 - increases
 - remains the same
- Which symbol represents a particle that has the same total number of electrons as S^{2-} ?
 - O^{2-}
 - Si
 - Se^{2-}
 - Ar
- The elements Li and F combine to form an ionic compound. The electron configurations in this compound are the same as the electron configurations of atoms in Group
 - 1
 - 14
 - 17
 - 18
- Which properties are characteristic of the Group 1 metals?
 - high reactivity and the formation of stable compounds
 - high reactivity and the formation of unstable compounds
 - low reactivity and the formation of stable compounds
 - low reactivity and the formation of unstable compounds
- Which is the correct electron-dot formula for a molecule of chlorine?
 - $\begin{array}{ccc} \cdot\cdot & \cdot\cdot & \\ \cdot\text{Cl} & ; & \text{Cl}\cdot \\ \cdot\cdot & \cdot\cdot & \end{array}$
 - $\begin{array}{ccc} \cdot\cdot & \cdot\cdot & \\ \cdot\text{Cl} & ; & \text{Cl} : \\ \cdot\cdot & \cdot\cdot & \end{array}$
 - $\begin{array}{ccc} \cdot\cdot & \cdot\cdot & \\ & & \text{Cl} : : \text{Cl} : \\ \cdot\cdot & \cdot\cdot & \end{array}$
 - $\begin{array}{ccc} \cdot\cdot & \cdot\cdot & \\ & & \text{Cl} : : \text{Cl} : \\ \cdot\cdot & \cdot\cdot & \end{array}$

Base your answers to questions 6 and 7 on your knowledge of chemical bonding and on the Lewis electron-dot diagrams of H_2S , CO_2 , and F_2 below.



- Which atom, when bonded as shown, has the same electron configuration as an atom of argon?
 - Ne
 - Cl
 - Ca
 - Na
- Explain, in terms of electronegativity, why a C-O bond in CO_2 is more polar than the F-F bond in F_2 .

- Which of these elements has an atom with the most stable outer electron configuration?
 - Ne
 - Cl
 - Ca
 - Na
- When a sodium atom reacts with a chlorine atom to form a compound, the electron configurations of the ions forming the compound are the same as those in which noble gas atoms?
 - krypton and neon
 - krypton and argon
 - neon and helium
 - neon and argon
- Based on electronegativity values, which type of elements tends to have the greatest attraction for electrons in a bond?
 - metals
 - metalloids
 - nonmetals
 - noble gases
- Which element has atoms with the greatest attraction for electrons in a chemical bond?
 - beryllium
 - fluorine
 - lithium
 - oxygen
- Based on your Reference Tables, the atoms of which of these elements have the strongest attraction for electrons in a chemical bond?
 - N
 - Na
 - P
 - Pt
- Which bond is *least* polar?
 - As-Cl
 - Bi-Cl
 - P-Cl
 - N-Cl
- If the electronegativity difference between the elements in compound NaX is 2.1, what is element X?
 - bromine
 - chlorine
 - fluorine
 - oxygen

19. Given the electron dot diagram:



The electrons in the bond between hydrogen and fluorine are more strongly attracted to the atom of

- hydrogen, which has the higher electronegativity
 - fluorine, which has the higher electronegativity
 - hydrogen, which has the lower electronegativity
 - fluorine, which has the lower electronegativity
20. Which of the following elements has the greatest ability to attract electrons?
- Li
 - Be
 - Na
 - Mg
21. An element with an electronegativity of 0.9 bonds with an element with an electronegativity of 3.1. Which phrase best describes the bond between these elements?
- mostly ionic in character and formed between two nonmetals
 - mostly ionic in character and formed between a metal and a nonmetal
 - mostly covalent in character and formed between two nonmetals
 - mostly covalent in character and formed between a metal and a nonmetal
22. Electronegativity is a measure of an atom's ability to
- attract the electrons in the bond between the atom and another atom
 - repel the electrons in the bond between the atom and another atom
 - attract the protons of another atom
 - repel the protons of another atom
23. Which type of bonding is usually exhibited when the electronegativity difference between two atoms is 1.1?
- ionic
 - covalent
 - metallic
 - network
24. Which compound has the least ionic character?
- KCl
 - CaCl₂
 - AlCl₃
 - CCl₄
25. Which bond has the least ionic character?
- KBr
 - HF
 - MgO
 - BrCl
26. Which compound contains a bond with the least ionic character?
- CO
 - CaO
 - K₂O
 - Li₂O
27. Which formula represents an ionic compound?
- H₂
 - CH₄
 - CH₃OH
 - NHCl
28. Which substance contains bonds that involved the transfer of electrons from one atom to another?
- CO₂
 - NH₃
 - KBr
 - Cl₂
29. Which type of bond results when one or more valence electrons are transferred from one atom to another?
- a hydrogen bond
 - an ionic bond
 - a nonpolar covalent bond
 - a polar covalent bond
30. Which type of bond is found in sodium bromide?
- covalent
 - hydrogen
 - ionic
 - metallic
31. Compared to a calcium atom, the calcium ion Ca²⁺ has
- more protons
 - fewer protons
 - more electrons
 - fewer electrons
32. What occurs when an atom loses an electron?
- The atom's radius decreases and the atom becomes a negative ion.
 - The atom's radius decreases and the atom becomes a positive ion.
 - The atom's radius increases and the atom becomes a negative ion.
 - The atom's radius increases and the atom becomes a positive ion.
33. As a chlorine atom becomes a negative ion, the atom
- gains an electron and its radius increases
 - gains an electron and its radius decreases
 - loses an electron and its radius increases
 - loses an electron and its radius decreases
34. Which compound contains both ionic and covalent bonds?
- CaCO₃
 - PCl₃
 - MgF₂
 - CH₂O
35. Which sample contains particles in a rigid, fixed, geometric pattern?
- CO₂(aq)
 - HCl(g)
 - H₂O(l)
 - KCl(s)
36. Based on bond type, which compound has the highest melting point?
- CH₃OH
 - C₆H₁₄
 - CaCl₂
 - CCl₄
37. Which substance is an electrolyte?
- CH₃OH
 - C₆H₁₂O₆
 - H₂O
 - KOH

50. In which material are the particles arranged in a regular geometric pattern?

- 1) $\text{CO}_2(\text{g})$ 3) $\text{H}_2\text{O}(\ell)$
 2) $\text{NaCl}(\text{aq})$ 4) $\text{C}_{12}\text{H}_{22}\text{O}_{11}(\text{s})$

51. A chemist performs the same tests on two homogeneous white crystalline solids, *A* and *B*. The results are shown in the table below.

	Solid A	Solid B
Melting Point	High, 801°C	Low, decomposes at 186°C
Solubility in H_2O (grams per 100.0 g H_2O at 0°C)	35.7	3.2
Electrical Conductivity (in aqueous solution)	Good conductor	Nonconductor

The results of these tests suggest that

- 1) both solids contain only ionic bonds
 2) both solids contain only covalent bonds
 3) solid *A* contains only covalent bonds and solid *B* contains only ionic bonds
 4) solid *A* contains only ionic bonds and solid *B* contains only covalent bonds

52. Which type of substance is soft, has a low melting point, and is a poor conductor of heat and electricity?

- 1) network solid 3) metallic solid
 2) molecular solid 4) ionic solid

53. What is the maximum number of covalent bonds that a carbon atom can form?

- 1) 1 3) 3
 2) 2 4) 4

54. Conductivity in a metal results from the metal atoms having

- 1) high electronegativity
 2) high ionization energy
 3) highly mobile protons in the nucleus
 4) highly mobile electrons in the valence shell

55. Which substance contains metallic bonds?

- 1) $\text{Hg}(\ell)$ 3) $\text{NaCl}(\text{s})$
 2) $\text{H}_2\text{O}(\ell)$ 4) $\text{C}_6\text{H}_{12}\text{O}_6(\text{s})$

56. The high electrical conductivity of metals is primarily due to

- 1) high ionization energies 3) mobile electrons
 2) filled energy levels 4) high electronegativities

57. Metallic bonding occurs between atoms of

- 1) sulfur 3) fluorine
 2) copper 4) carbon

58. Which compound has hydrogen bonding between its molecules?

- 1) CH_4 3) KH
 2) CaH_2 4) NH_3

59. The degree of polarity of a chemical bond in a molecule of a compound can be predicted by determining the difference in the

- 1) melting points of the elements in the compound
 2) densities of the elements in the compound
 3) electronegativities of the bonded atoms in a molecule of the compound
 4) atomic masses of the bonded atoms in a molecule of the compound

60. Which formula represents a nonpolar molecule containing polar covalent bonds?

- 1) H_2O 3) NH_3
 2) CCl_4 4) H_2

61. Which formula represents a nonpolar molecule?

- 1) CH_4 3) H_2O
 2) HCl 4) NH_3

62. The bonds between hydrogen and oxygen in a water molecule are classified as

- 1) polar covalent 3) ionic
 2) nonpolar covalent 4) metallic

63. At STP, fluorine is a gas and bromine is a liquid because, compared to fluorine, bromine has

- 1) stronger covalent bonds
 2) stronger intermolecular forces
 3) weaker covalent bonds
 4) weaker intermolecular forces

64. Which statement explains why low temperature and high pressure are required to liquefy chlorine gas?
- 1) Chlorine molecules have weak covalent bonds.
 - 2) Chlorine molecules have strong covalent bonds.
 - 3) Chlorine molecules have weak intermolecular forces of attraction.
 - 4) Chlorine molecules have strong intermolecular forces of attraction.
65. Which formula represents a nonpolar molecule?
- 1) H_2S
 - 2) HCl
 - 3) CH_4
 - 4) NH_3
66. At STP, fluorine is a gas and iodine is a solid. This observation can be explained by the fact that fluorine has
- 1) weaker intermolecular forces of attraction than iodine
 - 2) stronger intermolecular forces of attraction than iodine
 - 3) lower average kinetic energy than iodine
 - 4) higher average kinetic energy than iodine
67. Which formula represents a nonpolar molecule?
- 1) HCl
 - 2) H_2O
 - 3) NH_3
 - 4) CF_4
68. Explain, in terms of electronegativity, why a P-Cl bond in a molecule of PCl_5 is more polar than a P-S bond in a molecule of P_2S_5 .
69. Explain, in terms of molecular structure or distribution of charge, why a molecule of methane is nonpolar.

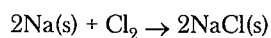
Base your answers to questions 70 through 74 on the table below.

Physical Properties of Four Gases

Name of Gas	hydrogen	hydrogen chloride	hydrogen bromide	hydrogen iodide
Molecular Structure	H-H	H-Cl	H-Br	H-I
Boiling Point (K) at 1 Atm	20.	188	207	237
Density (g/L) at STP	0.0899	1.64	?	5.66

70. Explain, in terms of molecular polarity, why hydrogen chloride is more soluble than hydrogen in water under the same conditions of temperature and pressure.
71. Explain, in terms of intermolecular forces, why hydrogen has a *lower* boiling point than hydrogen bromide.
72. Explain, in terms of electronegativity difference, why the bond in H-Cl is more polar than the bond in H-I.
73. The density of hydrogen at STP is 0.0899 gram per liter. Express this density to *two significant figures*.
74. The volume of 1.00 mole of hydrogen bromide at STP is 22.4 liters. The gram-formula mass of hydrogen bromide is 80.9 grams per mole. What is the density of hydrogen bromide at STP?

Base your answers to questions 75 and 76 on the balanced equation below.



75. Explain, in terms of electrons, why the bonding in NaCl is ionic.
76. Draw a Lewis electron-dot diagram for a molecule of chlorine, Cl_2 .

Base your answers to questions 77 through 80 on the information below.

Each molecule listed below is formed by sharing electrons between atoms when the atoms within the molecule are bonded together.

Molecule *A*: Cl_2
Molecule *B*: CCl_4
Molecule *C*: NH_3

77. Explain how the bonding in KCl is different from the bonding in molecules *A*, *B*, and *C*.

78. Explain why NH_3 has stronger intermolecular forces of attraction than Cl_2 .

79. Explain why CCl_4 is classified as a nonpolar molecule.

80. Draw the electron-dot (Lewis) structure for the NH_3 molecule.

81. *a* Draw *two* different compounds, one in each box, using the representations for atoms of element *X* and element *Z* given below.

Atom of element *X* = ○

Atom of element *Z* = ●

b Draw a mixture of these two compounds.

Answer Key
[New Exam]

1. 2

2. 3

3. 1

4. 3

5. 4

6. Sulfur

7. Responses include, but are not limited to: The electronegativity difference in a carbon-oxygen bond is greater than the electronegativity difference in a fluorine-fluorine bond • The EN difference for C and O is 0.9 and the EN difference for F and F is 0.

8. 1

9. 4

10. 4

11. 1

12. 4

13. 2

14. 3

15. 2

16. 1

17. 4

18. 1

19. 2

20. 2

21. 2

22. 1

23. 2

24. 4

25. 4

26. 1

27. 4

28. 3

29. 2

30. 3

31. 4

32. 2

33. 1

34. 1

35. 4

36. 3

37. 4

38. 2

39. 1

40. 4

41. 1

42. 4

43. 2

44. 3

45. 1

46. 4

47. 1

48. 3

49. 3

50. 4

51. 4

52. 2

53. 4

54. 4

55. 1

56. 3

57. 2

58. 4

Answer Key
[New Exam]

59. 3

60. 2

61. 1

62. 1

63. 2

64. 3

65. 3

66. 1

67. 4

68. A P-Cl bond is more polar than a P-S bond because the electronegativity difference for P-Cl is 1.0 and the electronegativity difference for P-S is 0.4.

69. *Examples:* --Methane is nonpolar because its molecules are symmetrical. --Charges are evenly distributed throughout the molecule.

70. *Examples:* - HCl's molecular polarity is more similar to water's polarity than H₂'s polarity compared to water's - HCl and water both polar, H₂ nonpolar, like dissolves like - HCl polarity is more similar to water's polarity

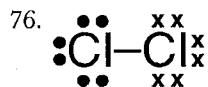
71. *Examples:* - Hydrogen has weaker intermolecular forces than HBr. - hydrogen - weaker forces.

72. *Examples:* - The electronegativity difference for HCl is 1.1, which is higher than the 0.6 for HI. - The difference for HCl is greater.

73. 0.090 g/L or 9.0×10^{-2} g/L

74. 3.61 g/L

75. The sodium atom transfers its one valence electron to the chlorine atom.



77. *Examples:*

- KCl - ionic bond; A, B, C - no ionic bonds
- Atoms do not share electrons when bonding.
- There is a transfer of electrons from K to Cl.
- KCl forms by electrostatic attraction.
- Bonding involves a metal with a nonmetal.

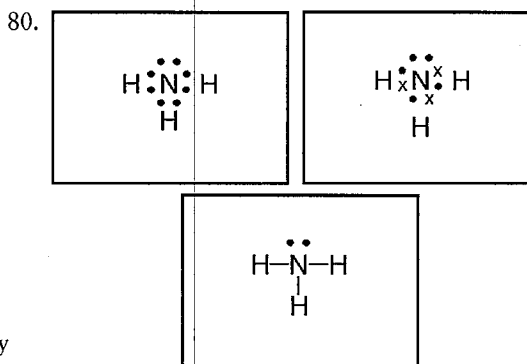
78. *Examples:*

- NH₃ has polar molecules that attract each other.
- NH₃ has an unshared pair of electrons around the center atom.
- NH₃ is capable of hydrogen bonding.

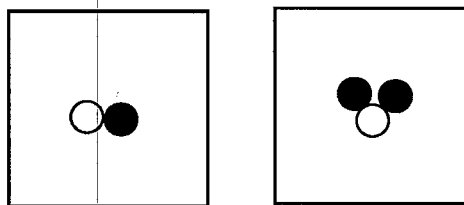
- unequal distribution of electrons - in strong attraction

79. *Examples:*

- The molecule is symmetrical in shape and/or charge.
- Electrons are evenly distributed.
- All polar covalent dipoles cancel - no dipole moments.
- no dipoles



81. *a*



b

