

1. A barium atom attains a stable electron configuration when it bonds with

- (A) one chlorine atom (B) **two chlorine atoms**
(C) one sodium atom (D) two sodium atoms

2. Which symbol represents an atom in the ground state with the most stable valence electron configuration?

- (A) B (B) O (C) Li (D) **Ne**

3. Which is the correct electron-dot formula for a molecule of chlorine?

- (A) $\begin{array}{c} \cdot\cdot \quad \cdot\cdot \\ \cdot\text{Cl} : \text{Cl}\cdot \\ \cdot\cdot \quad \cdot\cdot \end{array}$ (B) $\begin{array}{c} \cdot\cdot \quad \cdot\cdot \\ : \text{Cl} : : \text{Cl} : \\ \cdot\cdot \quad \cdot\cdot \end{array}$
(C) $\begin{array}{c} \cdot\cdot \quad \cdot\cdot \\ : \text{Cl} : : \text{Cl} : \\ \cdot\cdot \quad \cdot\cdot \end{array}$ (D) $\begin{array}{c} \cdot\cdot \quad \cdot\cdot \\ : \text{Cl} : \text{Cl} : \\ \cdot\cdot \quad \cdot\cdot \end{array}$

4. Which bond is *least* polar?

- (A) As-Cl (B) Bi-Cl
(C) P-Cl (D) **N-Cl**

5. Given the electron dot diagram:



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

- (A) hydrogen, which has the higher electronegativity
(B) **fluorine, which has the higher electronegativity**
(C) hydrogen, which has the lower electronegativity
(D) fluorine, which has the lower electronegativity

6. Which pair of elements below will form a compound with the greatest ionic character?

- (A) Pb and F (B) **Ca and O**
(C) Na and Cl (D) Cs and N

7. Which atom will form the most polar bond with the greatest degree of ionic bonding when bonding with sodium?

- (A) **F** (B) Cl (C) I (D) Br

8. Two atoms with an electronegativity difference of 0.4 form a bond that is

- (A) ionic, because electrons are shared
(B) ionic, because electrons are transferred
(C) **covalent, because electrons are shared**
(D) covalent, because electrons are transferred

9. The bonds in BaO are best described as

- (A) covalent, because valence electrons are shared
(B) covalent, because valence electrons are transferred
(C) ionic, because valence electrons are shared
(D) **ionic, because valence electrons are transferred**

10. Which compound contains both ionic and covalent bonds?

- (A) ammonia (B) methane
(C) **sodium nitrate** (D) potassium chloride

11. Compared to a calcium atom, the calcium ion Ca^{2+} has

- (A) more protons (B) fewer protons
(C) more electrons (D) **fewer electrons**

12. What occurs when an atom loses an electron?

- (A) The atom's radius decreases and the atom becomes a negative ion.
(B) **The atom's radius decreases and the atom becomes a positive ion.**
(C) The atom's radius increases and the atom becomes a negative ion.
(D) The atom's radius increases and the atom becomes a positive ion.

13. As a chlorine atom becomes a negative ion, the atom

- A gains an electron and its radius increases**
- B gains an electron and its radius decreases
- C loses an electron and its radius increases
- D loses an electron and its radius decreases

14. Which statement best describes the substance that results when electrons are transferred from a metal to a nonmetal?

- A It contains ionic bonds and has a low melting point.
- B It contains ionic bonds and has a high melting point.**
- C It contains covalent bonds and has a low melting point.
- D It contains covalent bonds and has a high melting point.

15. Which ion contains the same total number of electrons as Cl^- ?

- A S^{2-}**
- B Br^-
- C Mg^{2+}
- D Na^+

16. Which formula correctly represents the compound calcium hydroxide?

- A CaOH
- B Ca_2OH
- C CaOH_2
- D $\text{Ca}(\text{OH})_2$**

17. Which of the following solids has the highest melting point?

- A $\text{H}_2\text{O}(\text{s})$
- B $\text{Na}_2\text{O}(\text{s})$**
- C $\text{SO}_2(\text{s})$
- D $\text{CO}_2(\text{s})$

18. Which type of bonding is characteristic of a substance that has a high melting point and electrical conductivity only in the liquid phase?

- A nonpolar covalent
- B coordinate covalent
- C ionic**
- D metallic

19. What is the total number of electrons shared in a double covalent bond?

- A 1
- B 2
- C 3
- D 4**

20. The nitrogen atoms in a molecule of N_2 share a total of

- A one pair of electrons
- B one pair of protons
- C three pairs of electrons**
- D three pairs of protons

21. As a bond between a hydrogen atom and a sulfur atom is formed, electrons are

- A shared to form an ionic bond
- B shared to form a covalent bond**
- C transferred to form an ionic bond
- D transferred to form a covalent bond

22. Which two substances are covalent compounds?

- A $\text{C}_6\text{H}_{12}\text{O}_6(\text{s})$ and $\text{KI}(\text{s})$
- B $\text{C}_6\text{H}_{12}\text{O}_6(\text{s})$ and $\text{HCl}(\text{g})$**
- C $\text{KI}(\text{s})$ and $\text{NaCl}(\text{s})$
- D $\text{NaCl}(\text{s})$ and $\text{HCl}(\text{g})$

23. What is the total number of electrons shared in the bonds between the two carbon atoms in the molecule shown below?



- A 6**
- B 2
- C 3
- D 8

24. Which formula represents a substance that contains covalent bonds?

- A LiCl
- B CaCl_2
- C K_2O
- D CO_2**

25. Which characteristic is a property of molecular substances?

- (A) good heat conductivity
- (B) good electrical conductivity
- (C) **low melting point**
- (D) high melting point

26. 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 ₂ O (grams per 100.0 g H ₂ O at 0°C)	35.7	3.2
Electrical Conductivity (in aqueous solution)	Good conductor	Nonconductor

The results of these tests suggest that

- (A) both solids contain only ionic bonds
- (B) both solids contain only covalent bonds
- (C) solid *A* contains only covalent bonds and solid *B* contains only ionic bonds
- (D) **solid *A* contains only ionic bonds and solid *B* contains only covalent bonds**

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

- (A) 1
- (B) 2
- (C) 3
- (D) 4

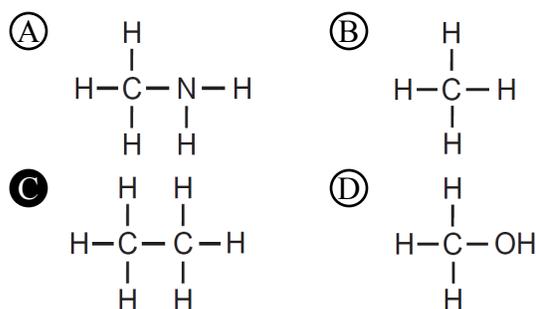
28. Which type of bond is found between atoms of solid cobalt?

- (A) nonpolar covalent
- (B) polar covalent
- (C) **metallic**
- (D) ionic

29. A solid substance is an excellent conductor of electricity. The chemical bonds in this substance are most likely

- (A) ionic, because the valence electrons are shared between atoms
- (B) ionic, because the valence electrons are mobile
- (C) metallic, because the valence electrons are stationary
- (D) **metallic, because the valence electrons are mobile**

30. Which formula represents a molecule having a nonpolar covalent bond?



31. The chemical bond between which two atoms is most polar?

- (A) C-N
- (B) H-H
- (C) S-Cl
- (D) **Si-O**

32. Which compound has hydrogen bonding between its molecules?

- (A) CH₄
- (B) CaH₂
- (C) KH
- (D) **NH₃**

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

- (A) melting points of the elements in the compound
- (B) densities of the elements in the compound
- (C) **electronegativities of the bonded atoms in a molecule of the compound**
- (D) atomic masses of the bonded atoms in a molecule of the compound

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

- (A) H_2O (B) CCl_4 (C) NH_3 (D) H_2

35. Which type of molecule is CF_4 ?

- (A) polar, with a symmetrical distribution of charge
 (B) polar, with an asymmetrical distribution of charge
 (C) **nonpolar, with a symmetrical distribution of charge**
 (D) nonpolar, with an asymmetrical distribution of charge

36. Which of the following compounds has the highest boiling point?

- (A) H_2O (B) H_2S (C) H_2Se (D) H_2Te

37. Which compound has molecules that form the strongest hydrogen bonds?

- (A) HI (B) HBr (C) HF (D) HCl

38. Which bond is most polar?

- (A) $\text{H}-\text{F}$ (B) $\text{H}-\text{Cl}$
 (C) $\text{H}-\text{Br}$ (D) $\text{H}-\text{I}$

39. In a nonpolar covalent bond, electrons are

- (A) **shared equally by two atoms**
 (B) shared unequally by two atoms
 (C) transferred from one atom to another
 (D) located in a mobile "sea" shared by many atoms

40. Given the formula representing a molecule:



The molecule is

- (A) symmetrical and polar
 (B) **symmetrical and nonpolar**
 (C) asymmetrical and polar
 (D) asymmetrical and nonpolar

41. Which formula represents a nonpolar molecule?

- (A) HCl (B) H_2O (C) NH_3 (D) CH_4

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

- (A) stronger covalent bonds
 (B) **stronger intermolecular forces**
 (C) weaker covalent bonds
 (D) weaker intermolecular forces

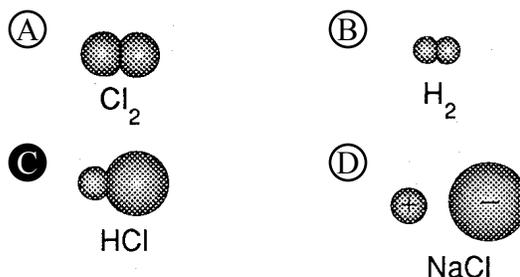
43. Which substance is correctly paired with its type of bonding?

- (A) NaBr —nonpolar covalent
 (B) HCl —nonpolar covalent
 (C) NH_3 —**polar covalent**
 (D) Br_2 —polar covalent

44. Which of these substances has the strongest intermolecular forces?

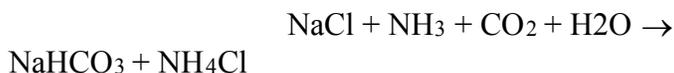
- (A) H_2O (B) H_2S (C) H_2Se (D) H_2Te

45. Which diagram best represents a polar molecule?



Base your answers to questions **46** through **48** on the information below.

In 1864, the Solvay process was developed to make soda ash. One step in the process is represented by the balanced equation below.



46. In the space draw a Lewis electron-dot diagram for the reactant containing nitrogen in the equation.
47. Explain, in terms of electronegativity difference, why the bond between hydrogen and oxygen in a water molecule is more polar than the bond between hydrogen and nitrogen in an ammonia molecule.
48. Write the chemical formula for *one compound in the equation that contains both ionic bonds and covalent bonds*.

Base your answers to questions **49** and **50** on the information below.

Ozone, $\text{O}_3(\text{g})$, is produced from oxygen, $\text{O}_2(\text{g})$ by electrical discharge during thunderstorms. The unbalanced equation below represents the reaction that forms ozone.



49. Explain, in terms of electron configuration, why an oxygen molecule is more stable than an oxygen atom.

50. Identify the type of bonding between the atoms in an oxygen molecule.

Base your answers to questions 51 and 52 on the information below.

**Physical Properties of CF₄ and NH₃
at Standard Pressure**

Compound	Melting Point (°C)	Boiling Point (°C)	Solubility in Water at 20.0°C
CF ₄	-183.6	-127.8	insoluble
NH ₃	-77.7	-33.3	soluble

51. In the space *in your answer booklet*, draw a Lewis electron-dot diagram for CF₄.

52. State evidence that indicates NH₃ has stronger intermolecular forces than CF₄.

53. Explain, in terms of electronegativity difference, why the bond in a molecule of HF is more polar than the bond in a molecule of HI.

54. Explain, in terms of valence electrons, why the bonding in magnesium oxide, MgO, is similar to the bonding in barium chloride, BaCl₂.

55. What is the total number of electron pairs shared between the carbon atom and one of the oxygen atoms in a carbon dioxide molecule?

56. Base your answer to the following question on the information below.

At STP, iodine, I_2 , is a crystal, and fluorine, F_2 , is a gas. Iodine is soluble in ethanol, forming a tincture of iodine. A typical tincture of iodine is 2% iodine by mass.

Draw a Lewis electron-dot diagram for a molecule of I_2 .

57. Base your answer to the following question on the information below.

At STP, iodine, I_2 , is a crystal, and fluorine, F_2 , is a gas. Iodine is soluble in ethanol, forming a tincture of iodine. A typical tincture of iodine is 2% iodine by mass.

Compare the strength of the intermolecular forces in a sample of I_2 at STP to the strength of the intermolecular forces in a sample of F_2 at STP.

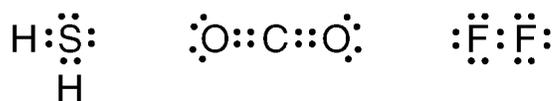
58. Base your answer to the following question on the following information.

A piece of magnesium ribbon is reacted with excess hydrochloric acid to produce aqueous magnesium chloride and hydrogen gas. The volume of the dry hydrogen gas produced is 45.6 milliliters. The temperature of the gas is 293 K, and the pressure is 99.5 kilopascals.

Identify the type of bond between the atoms in a molecule of the gas produced in this laboratory investigation.

59. 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 .

60. Base your answer to the following question on your knowledge of chemical bonding and on the Lewis electron-dot diagrams of H₂S, CO₂, and F₂ below.



Explain, in terms of electronegativity, why a C–O bond in CO₂ is more polar than the F–F bond in F₂.

Base your answers to questions 61 through 63 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*: Cl₂

Molecule *B*: CCl₄

Molecule *C*: NH₃

61. Explain how the bonding in KCl is different from the bonding in molecules *A*, *B*, and *C*.
62. Explain why NH₃ has stronger intermolecular forces of attraction than Cl₂.
63. Explain why CCl₄ is classified as a nonpolar molecule.

64. The atom of which element has an ionic radius smaller than its atomic radius?

(A) N (B) S (C) Br (D) Rb

65. Base your answer to the following question on the information below.

A metal, M , was obtained from a compound in a rock sample. Experiments have determined that the element is a member of Group 2 on the Periodic Table of the Elements.

Explain why the radius of a positive ion of element M is *smaller* than the radius of an atom of element M .

66. Which element has an atomic radius that is greater than its ionic radius?

- A S B K C F D O

67. Which element has an ion with a radius that is larger than its atomic radius?

- A K B Cr C Zn D Cl

68. Which element's ionic radius is smaller than its atomic radius?

- A neon B nitrogen
 C sodium D sulfur

69. What is the total number of valence electrons in a sulfide ion in the ground state?

- A 8 B 2 C 16 D 18

70. What is the total number of electrons in a Mg^{2+} ion?

- A 10 B 12 C 14 D 24

71. What is the net charge on an ion that has 9 protons, 11 neutrons, and 10 electrons?

- A 1+ B 2+ C 1- D 2-

72. Which particle has the same electron configuration as a potassium ion?

- A fluoride ion B sodium ion
 C neon atom D argon atom

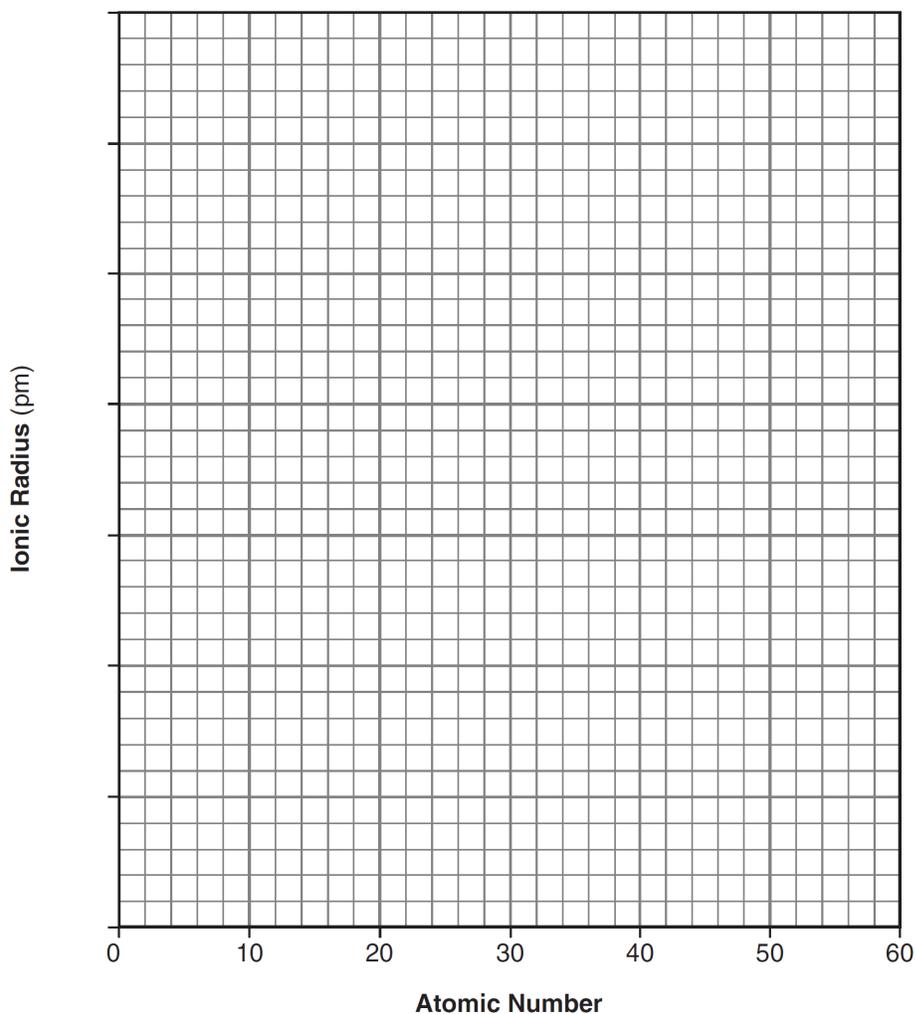
Base your answers to questions 73 through 77 on the information below.
The ionic radii of some Group 2 elements are given in the table below.

Ionic Radii of Some Group 2 Elements

Symbol	Atomic Number	Ionic Radius (pm)
Be	4	44
Mg	12	66
Ca	20	99
Ba	56	134

73. On the grid, mark an appropriate scale on the axis labeled "Ionic Radius (pm)."

Ionic Radius Versus Atomic Number



74. On the same grid, plot the data from the data table. Circle and connect the points.

75. Estimate the ionic radius of strontium.

76. State the trend in ionic radius as the elements in Group 2 are considered in order of increasing atomic number.

77. Explain, in terms of electrons, why the ionic radius of a Group 2 element is smaller than its atomic radius.

Answer Key

Unit 4 Chem Bonding Review

62. 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

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

64. **D**

65. Examples: – The ionic radius is smaller because the atom loses two electrons. – The ion has one less occupied energy level.

66. **B**

67. **D**

68. **C**

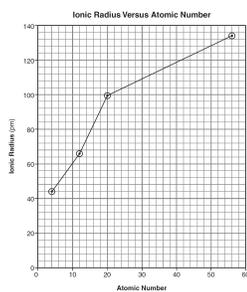
69. **A**

70. **A**

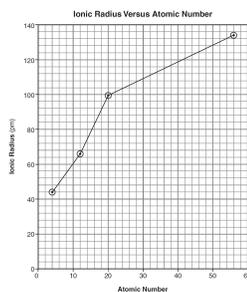
71. **C**

72. **D**

73.



74.



75. – 117 pm ± 2 pm

76. – As the atomic number of elements in Group 2 increases, the ionic radius increases.
– The ionic radius increases.

77. – The valence electron shell of a Group 2 atom is lost when it becomes an ion. – A Group 2 ion has two fewer electrons than the atom from which it was formed.