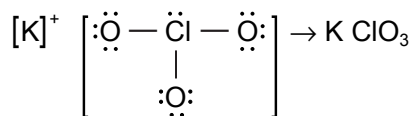
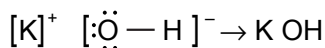
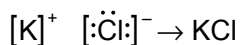


(b) KCl — potassium chloride, KOH — potassium hydroxide, KClO₃ — potassium chlorate.

(c) KCl — ionic, KOH — ionic, KClO₃ — ionic.



(d) KCl — binary, KOH — tertiary and basic, KClO₃ — tertiary.

(e) KCl — ionic bonds only, KOH — ionic and covalent bonds, KClO₃ — ionic and covalent bonds.

CHAPTER 2 SUMMARY

Make a Summary

(Page 102)

The examples of NaCl and H₂O are used in the table below. The student is to include as many examples of compounds as possible for each type of intramolecular bond.

Table 1: Summarizing Bonds and Forces

Compound	Properties	Electron dot diagram/ Lewis structure	Intramolecular bond type	Polarity	Intermolecular forces
NaCl	Solid at SATP, hard and brittle, high melting point, its solution conducts electricity.	$[Na]^+ [Cl]^-$ $[Na]^+ [\ddot{Cl}:]^-$	Ionic	Ionic	Locked in a regular structure, held by the balance of attractive bonds and electrical repulsion.
H ₂ O	Liquid at SATP, low boiling point.	H—O—H $\begin{array}{c} \delta^- \\ \cdot\cdot \\ \text{H} - \ddot{O} - \text{H} \\ \cdot\cdot \\ \delta^+ \end{array}$ or $\begin{array}{c} \delta^- \\ \cdot\cdot \\ \text{H} - \text{O} - \text{H} \\ \cdot\cdot \\ \delta^+ \end{array}$	Covalent	Polar	Hydrogen bonds.

Reflect on your Learning

(Page 102)

By the end of the chapter the student should have developed a more in-depth understanding of why atoms form compounds, an awareness of the many different compounds that are possible, the types of forces present between atoms in compounds, and how the forces that hold atoms together in a compound determine the chemical properties of the compound.

CHAPTER 2 REVIEW

(Page 103)

Understanding Concepts

- When elements that are found in the “metals” position in the periodic table react with elements that are found in the “nonmetals” position in the periodic table, they form ionic compounds that have ionic bonds. When elements that are found in the “nonmetals” position in the periodic table react with elements also found in the “nonmetals” position in the periodic table, they form molecular compounds that have covalent bonds.

2. An ionic bond occurs when one or more valence electrons are transferred from a metal atom to a nonmetal atom. This leaves the metal atom as a positive ion, or cation, and the nonmetal atom as a negative ion, or anion. An ionic bond is the electrostatic attraction between positive and negative ions in a compound.

A covalent bond arises from the simultaneous attraction of two nuclei for a shared pair of electrons. The result is a covalent bond — a shared pair of electrons held between two nonmetal atoms that hold the atoms together in a molecule.

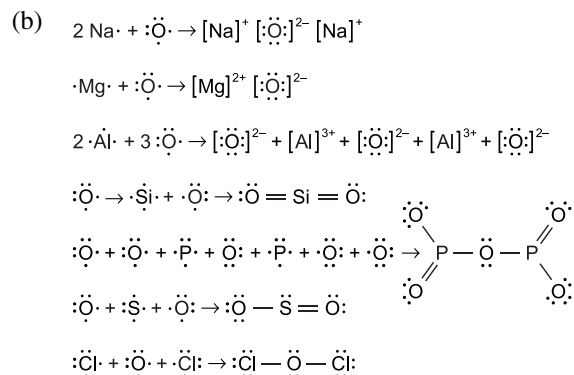
3. (a) The properties of ionic compounds: Are solid at SATP, with hard surfaces, are brittle, have high melting points, and form solutions that conduct electricity. The properties are due to the strong ionic bonds, simultaneous forces of attraction between the positive and negative ions, which hold the ions firmly in a rigid structure. The solid state, hardness, brittleness, and the high melting point result from the strong attractions, which occur in the crystal structure. And because the ionic bonds break down in water, the resulting ions are free to move in solution and conduct electricity.

The properties of molecular compounds: May be solids, liquids, or gases at SATP, and are soft, waxy, or flexible. Covalent bonds between the atoms are strong. However, the intermolecular forces in molecular compounds are weaker in comparison — adding a relatively small amount of heat will cause a solid molecular compound to change state from a solid to a liquid, and then to a gas.

- (b) Ionic compounds (many of which dissolve readily in water) form solutions that conduct electricity. Because the ionic bonds often break down in water, the resulting ions are free to move in solution and conduct electricity. Molecular compounds form solutions that do not generally conduct electricity.
4. (a) Intramolecular bonding is the force that bonds atoms and ions together in a compound. One main type of intramolecular bonding is ionic bonding. An example of ionic bonding is the electrostatic attraction that occurs between the $[\text{Na}]^+$ cation and the $[\text{Cl}]^-$ anion to form the ionic compound NaCl . Another main type of intramolecular bonding is covalent bonding. An example of covalent bonding is the sharing of a pair of electrons that occurs between hydrogen and chlorine to form the molecular compound HCl .
- (b) Ionic bonding results in compounds that are solid at SATP with hard surfaces, are brittle, have high melting points, and form solutions that conduct electricity. Covalent bonding results in compounds that may be solids, liquids, or gases at SATP, and are soft, waxy, or flexible. Covalently bonded compounds form solutions that do not generally conduct electricity.
5. (a) two nonmetal atoms that are sharing a pair of electrons
 (b) oppositely charged ends of polar molecules
 (c) a positive hydrogen atom of one molecule and a highly electronegative atom (F, O, or N) in another molecule
 (d) a positively charged ion (cation) of a metal and a negatively charged ion (anion) of a nonmetal
6. The chemical formulas of ionic compounds consist of a metal joined to a nonmetal. Examples are NaCl , CuSO_4 , and NaHCO_3 . The chemical formulas of molecular compounds consist of nonmetals combined with other nonmetals. Examples are SO_2 , CO_2 , and NH_3 .
7. Halogens tend to form diatomic molecules because they have only one bonding electron, and thus a capacity to bond with only one other atom.
8. Students will reproduce the bonding continuum of Figure 3 on p. 84. Cl_2 , with difference in electronegativities of 0, will be placed at the far right (covalent). NaCl , with an electronegativity difference of 2.1, should be placed left of centre, in the “ionic” area. Na-Cl involves an electron transfer, resulting in the formation of cations and anions that are attracted to each other. Cl-Cl involves equal sharing of a pair of electrons.

9. (a) $\text{Ca} \cdot \text{Ca} \cdot$ (e) $\text{S} \quad \begin{array}{c} \cdot\ddot{\text{S}}\cdot \\ \cdot\ddot{\text{S}}\cdot \end{array}$
 (b) $\text{Al} \quad \cdot\ddot{\text{Al}}\cdot$ (f) $\text{Br} \quad \begin{array}{c} \cdot\ddot{\text{Br}}\cdot \\ \cdot\ddot{\text{Br}}\cdot \end{array}$
 (c) $\text{K} \quad \text{K} \cdot$ (g) $\text{Ne} \quad \begin{array}{c} \cdot\ddot{\text{Ne}}\cdot \\ \cdot\ddot{\text{Ne}}\cdot \end{array}$
 (d) $\text{N} \quad \begin{array}{c} \cdot\ddot{\text{N}}\cdot \\ \cdot\ddot{\text{N}}\cdot \end{array}$

10. (a) covalent
 (b) polar covalent
 (c) polar covalent
 (d) ionic
 (e) ionic
 (f) ionic
11. (a) $\text{Na}_2\text{O}_{(\text{s})}$ is ionic, $\text{MgO}_{(\text{s})}$ is ionic, $\text{Al}_2\text{O}_{3(\text{s})}$ is ionic, $\text{SiO}_{2(\text{s})}$ is molecular, $\text{P}_2\text{O}_{5(\text{s})}$ is molecular, $\text{SO}_{2(\text{g})}$ is molecular, and $\text{Cl}_2\text{O}_{(\text{g})}$ is molecular.

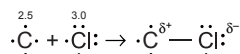


- (c) The ionic compounds are solid at SATP with hard surfaces, are brittle, have high melting points, and form solutions that conduct electricity. The molecular compounds may be solids, liquids, or gases at SATP, are soft, waxy, or flexible, and form solutions that do not generally conduct electricity.
- (d) The difference in electronegativity of the constituent elements determines whether the compound has ionic bonds or covalent-type bonds. An electronegativity difference greater than 1.7 indicates an ionic bond. Ionic bonds result in ionic properties, and covalent-type bonds result in molecular properties.

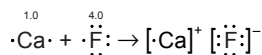
12. **Table 1:** Structures of Covalent Compounds

Compound	Lewis Structure	Structural Formula	Types of Bonds
$\text{HF}_{(g)}$	$\text{H} - \ddot{\text{F}}:$	$\text{H} - \text{F}$	Polar covalent
$\text{BCl}_{3(g)}$	$\begin{array}{c} :\ddot{\text{Cl}}: \\ \\ \text{B} \\ / \quad \backslash \\ :\ddot{\text{Cl}}: \quad :\ddot{\text{Cl}}: \end{array}$	$\begin{array}{c} \text{Cl} \\ \\ \text{B} \\ / \quad \backslash \\ \text{Cl} \quad \text{Cl} \end{array}$	Polar covalent
$\text{SiH}_{4(g)}$	$\begin{array}{c} \text{H} \\ \\ \text{H} - \text{Si} - \text{H} \\ \\ \text{H} \end{array}$	$\begin{array}{c} \text{H} \\ \\ \text{H} - \text{Si} - \text{H} \\ \\ \text{H} \end{array}$	Polar covalent
$\text{CCl}_{4(l)}$	$\begin{array}{c} :\ddot{\text{Cl}}: \\ \\ :\ddot{\text{Cl}} - \text{C} - \ddot{\text{Cl}}: \\ \\ :\ddot{\text{Cl}}: \end{array}$	$\begin{array}{c} \text{Cl} \\ \\ \text{Cl} - \text{C} - \text{Cl} \\ \\ \text{Cl} \end{array}$	Polar covalent
$\text{NCl}_{3(g)}$	$\begin{array}{c} \ddot{\text{N}} \\ / \quad \backslash \\ :\ddot{\text{Cl}}: \quad :\ddot{\text{Cl}}: \\ \\ :\ddot{\text{Cl}}: \end{array}$	$\begin{array}{c} \text{Cl} - \text{N} - \text{Cl} \\ \\ \text{Cl} \end{array}$	Polar covalent
$\text{H}_2\text{O}_{2(l)}$	$\text{H} - \ddot{\text{O}} - \ddot{\text{O}} - \text{H}$	$\text{H} - \text{O} - \text{O} - \text{H}$	Polar covalent and covalent
$\text{CO}_{2(g)}$	$:\ddot{\text{O}} = \text{C} = \ddot{\text{O}}:$	$\text{O} = \text{C} = \text{O}$	Polar covalent
$\text{HCN}_{(g)}$	$\text{H} - \text{C} \equiv \text{N}:$	$\text{H} - \text{C} \equiv \text{N}$	Polar covalent

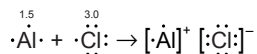
13. (a) Cl is most electronegative and will have a δ^- charge.



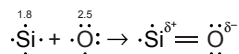
- (b) F is most electronegative and will have a δ^- charge.



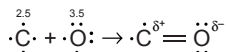
- (c) Cl is most electronegative and will have a δ^- charge.



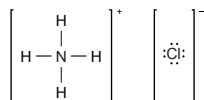
- (d) O is most electronegative and will have a δ^- charge.



- (e) O is most electronegative and will have a δ^- charge.

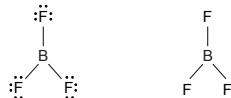


14. (a)



$\text{NH}_4\text{Cl}_{(\text{s})}$ contains a coordinate covalent bond. A hydrogen ion, which has no electrons of its own, has bonded to an $\text{NH}_3_{(\text{g})}$ molecule by sharing the unbonded, lone pair of electrons in $\text{NH}_3_{(\text{g})}$.

- (b)



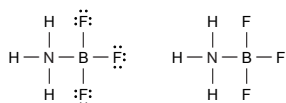
- (c)



- (d)



- (e)



$\text{NH}_3\text{BF}_3_{(\text{g})}$ contains a coordinate covalent bond. The boron in $\text{BF}_3_{(\text{g})}$, which does not have an octet in its valence shell, has bonded to NH_3 by sharing the unbonded, lone pair of electrons in NH_3 .

15. (a) $\text{NaHSO}_{4(\text{s})}$

- (b) $\text{NaOH}_{(\text{s})}$

- (c) $\text{CO}_{2(\text{g})}$

- (d) $\text{HC}_2\text{H}_3\text{O}_{2(\text{aq})}$

- (e) $\text{NaS}_2\text{O}_3 \cdot 5\text{H}_2\text{O}_{(\text{s})}$

- (f) $\text{NaClO}_{(\text{s})}$

- (g) $\text{S}_{8(\text{s})}$

16. (a) MgBr_2

- (b) CS_2

- (c) $\text{Hg}(\text{NO}_2)_2$

- (d) $\text{HCl}_{(\text{aq})}$

- (e) LiOH

- (h) $\text{NaNO}_{3(\text{s})}$

- (i) $\text{H}_3\text{PO}_{4(\text{aq})}$

- (j) $\text{I}_{2(\text{s})}$

- (k) $\text{Al}_2\text{O}_{3(\text{s})}$

- (l) $\text{KOH}_{(\text{s})}$

- (m) $\text{HCO}_{3(\text{aq})}$

- (n) $\text{H}_2\text{CO}_{3(\text{aq})}$

- (o) $\text{Ca}(\text{OH})_2$

- (p) $\text{Zn}(\text{ClO})_2$

- (q) $\text{Pb}(\text{ClO}_4)_4$

- (r) PBr_5

- (f) Ag_2CO_3 (s) AsCl_5
 (g) $\text{Al}(\text{ClO}_4)_3$ (t) $\text{Bi}(\text{NO}_3)_3$
 (h) CuSO_4 (u) NaClO
 (i) SO_3 (v) OCl_2
 (j) NiPO_4 (w) SnBr_2
 (k) MgO (x) $\text{H}_2\text{SO}_{4(\text{aq})}$
 (l) N_2O (y) KOH
 (m) FeSO_5 (z) BaCO_3
17. (a) $\text{NH}_4\text{H}_2\text{PO}_3$
 (b) LiHSO_3
 (c) KHSO_4
 (d) $\text{BaCl}_2 \cdot 3\text{H}_2\text{O}$
 (e) NaH_2PO_4
 (f) NaHCO_3
18. (a) calcium carbonate
 (b) diphosphorus pentoxide
 (c) magnesium sulfate heptahydrate
 (d) dinitrogen monoxide
 (e) sodium silicate
 (f) calcium hydrogen carbonate
 (g) hydrochloric acid
 (h) copper(II) sulfate pentahydrate
 (i) sulphuric acid
 (j) calcium hydroxide
 (k) sulfur trioxide
 (l) sodium fluoride
19. (a) sodium chloride (n) copper(II) carbonate
 (b) diphosphorus trioxide (o) aluminum sulfite
 (c) nitric acid (p) ammonium hydroxide
 (d) lead(II) acetate (q) barium acetate
 (e) ammonium hypochlorite (r) iodine monochloride
 (f) tin(IV) bromate (s) gold(III) chloride
 (g) antimony(III) oxide (t) magnesium sulfide
 (h) zinc iodate (u) dinitrogen difluoride
 (i) iron(II) pernitrate (v) nickel(II) sulfate
 (j) calcium hydroxide (w) hydrosulfuric acid
 (k) potassium iodide (x) silver bromate
 (l) sulfur difluoride (y) lithium perchlorate
 (m) hydrobromic acid
20. (a) calcium hydrogen phosphate
 (b) copper(II) sulfate heptahydrate
 (c) sodium hydrogen phosphate
 (d) lithium hydrogen carbonate
 (e) potassium hydrogen sulfate
21. (a) potassium bromide $\text{KBr}_{(\text{s})}$ $[\text{K}]^+ [:\ddot{\text{Br}}:]^-$
 (b) silver iodide $\text{AgI}_{(\text{s})}$ $[\text{Ag}]^+ [:\ddot{\text{I}}:]^-$
 (c) lead(II) oxide $\text{PbO}_{(\text{s})}$ $[\text{Pb}]^{2+} [:\ddot{\text{O}}:]^{2-}$
 (d) zinc sulfide $\text{ZnS}_{(\text{s})}$ $[\text{Zn}]^{2+} [:\ddot{\text{S}}:]^{2-}$
 (e) copper(II) oxide $\text{CuO}_{(\text{s})}$ $[\text{Cu}]^{2+} [:\ddot{\text{O}}:]^{2-}$
 (f) lithium nitride $\text{Li}_3\text{N}_{(\text{s})}$ $[\text{Li}]^{2+} [:\ddot{\text{N}}:]^{3-}$

Applying Inquiry Skills

22. (a) Analysis

Substance 1 is an ionic compound: $\text{KCl}_{(\text{aq})}$

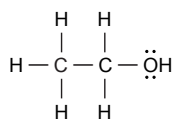
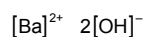
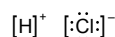
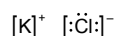
Substance 2 is an acid: $\text{HCl}_{(\text{aq})}$

Substance 3 is soluble but not ionic: $\text{C}_2\text{H}_5\text{OH}_{(\text{aq})}$

Substance 4 is a base: $\text{Ba}(\text{OH})_{2(\text{aq})}$

Synthesis

- (b) The water is used as a control. The result of the conductivity and litmus tests is the dependent variable. The different substances that are dissolved in water are the independent variables. Since water is used to prepare the solutions for each of the different substances, any change in the dependent variable from the control results can be attributed to the changing independent variable.
- (c) Solutions 1, 2, and 4 all have high conductivities, and could have been involved in somebody getting electrocuted; however, the most likely to have been involved is KCl. If the solutions were of high concentration, it seems possible that the lawsuit would have been about corrosion rather than electrocution if the substance involved were the acid or the base. When KCl, HCl, and $\text{Ba}(\text{OH})_2$ are dissolved in water, the positive and negative ions dissociate. The ions can then carry an electrical current. The electronegativity differences between the constituent atoms of $\text{C}_2\text{H}_5\text{OH}$ result in polar covalent bonds — $\text{C}_2\text{H}_5\text{OH}$ is a polar molecule. With $\text{C}_2\text{H}_5\text{OH}$ there are no positive and negative ions to dissociate, so the solution does not conduct electricity and could not have been involved in an electrocution.



Making Connections

23. (a) The student is to use the Internet to determine the IUPAC name and chemical formula for sal volatile. Ammonium carbonate: $(\text{NH}_4)_2\text{CO}_3$
- (b) The student is to predict the properties of the substance based upon the nature of the bonds. It is an ionic compound of the NH_4^+ and CO_3^{2-} ions. Students would predict that it is a solid, white, hard, and is highly soluble in water (hydrogen bonding). It is actually volatile at room temperature and even more so upon slight heating, releasing ammonia, water, and carbon dioxide.
- (c) The student is to explain how the properties of the substance relate to the strong, sharp, ammonia smell. The release of ammonia ($\text{NH}_3(\text{g})$) is responsible for the odour.
- (d) The student is to use the Internet to find out how smelling salts used to be administered, how they worked, and comment on the safety concerns that this use would raise today. A bottle containing the salt, or the salt in an ammonia–water solution, was waved under the nose of the unconscious person. Human noses are extremely sensitive to ammonia, because it is relatively common in nature and also toxic. If our noses detect the smell of toxic chemicals, this information, vitally important for survival, can bypass the temporary shutdown that is characteristic of some forms of unconsciousness and “shock” the victim into consciousness. Ammonia dissolves readily in water, forming a basic solution that could damage the lining of the respiratory tract and the lungs. (Unconsciousness should also be respected. It is a defence of the body — shutting down consciousness prevents the brain, in an addled state caused by oxygen or nutrient deprivation or severe bodily trauma, from instructing the body to do something that endangers survival (like moving, for example). It also reduces the metabolic requirements of the brain in a time of shortage, preventing cell death.

 GO TO www.science.nelson.com, Chemistry 11, Teacher Centre.

24. The student is to use the Internet to research the structure of boron nitride. Crystals with a hexagonal, graphite lattice are the most common form of boron nitride.

 GO TO www.science.nelson.com, Chemistry 11, Teacher Centre.

25. The student is to use the Internet to research the foods that use glycerol, the physical and chemical properties of glycerol, the chemical formula and molecular shape of glycerol, and to use the knowledge of the molecular shape and intra- and intermolecular bonding to explain at least three of the properties of glycerol. The student is also to write a short report, outlining why glycerol is so useful to the food industry.
- (a) In addition to the uses mentioned in the question, it is added to tobacco to keep it moist, and also to fruits, for the same purpose.
 - (b) Glycerol is also known as propanetriol (IUPAC), glyceryl alcohol, and glycerine. At SATP it is a viscous liquid with a sweet taste. It dissolves readily in water (antifreeze). It reacts with a rather large range of organic substances, and with acids to produce esters.
 - (c) $\text{CH}_2\text{OHCHOHCH}_2\text{OH}$; the molecule is polar and forms hydrogen bonds (explaining its solubility in water and its usefulness as a moistening agent, and also its viscosity in pure form).

 GO TO www.science.nelson.com, Chemistry 11, Teacher Centre.

Exploring

26. The student is to use the Internet to research Fritz London's work on intermolecular forces, and to write a brief report on his major findings. Dr. London (1900–1954) was born in what is now Wroclaw in Poland but was at that time Breslau in Germany. He emigrated to the United States in 1939 and became a citizen in 1945. A physicist and theoretical chemist, he worked on superconductivity, superfluids, and quantum chemistry (and is, of course, the London after whom London forces were named).

 GO TO www.science.nelson.com, Chemistry 11, Teacher Centre.