(e) potassium permanganate, $KMnO_4$
(f) ammonium chloride, $NH_4Cl$
(g) calcium phosphate, $Ca_3(PO_4)_2$
(h) sodium thiosulphate, $Na_2S_2O_3$

4. (a) VO, vanadium(II) oxide
$VO_2$, vanadium(IV) oxide
$V_2O_3$, vanadium(III) oxide
$V_2O_5$, vanadium(V) oxide
(b) FeS, iron(II) sulfide, ferrous sulfide
$Fe_2S_3$, iron(III) sulfide, ferric sulfide
(c) NiO, nickel(II) oxide, nickelous oxide
$Ni_2O_3$, nickel(III) oxide, nickelic oxide

5. The oxide ion is $O^{2-}$, thus the peroxide ion is $O_2^{2-}$, which is a polyatomic ion. The formula of the polyatomic ion must be kept intact when writing formulas. Therefore, hydrogen peroxide's formula must be written as $H_2O_2$ and not HO.

## Chapter 3 Review Answers

**Student Textbook pages 29–31**

### Answers to Knowledge/Understanding Questions

1. Electron affinity is an actual measure of the energy released or absorbed by an atom when an electron is added to the atom to form a negative ion. Electronegativity is a number, derived from a formula that includes factors such as electron affinity and ionization potential, that indicates an element's ability to attract electrons within a chemical bond.

2. (a) Zn–O, $\Delta EN = EN\ \text{O} - EN\ \text{Zn} = 3.44 - 1.65 = 1.79$
(b) Mg–I, $\Delta EN = EN\ \text{I} - EN\ \text{Mg} = 2.66 - 1.31 = 1.35$
(c) Co–Cl, $\Delta EN = EN\ \text{Cl} - EN\ \text{Co} = 3.16 - 1.88 = 1.28$
(d) N–O, $\Delta EN = EN\ \text{O} - EN\ \text{N} = 3.44 - 3.04 = 0.40$

3. (a) ionic
(b) polar covalent
(c) polar covalent
(d) covalent

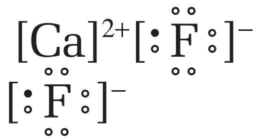
4. Covalent compounds have low melting and boiling points; are soft solids, gases, or liquids at room temperature; do not conduct electricity in solution or in liquid state; and may or may not be soluble in water.
Ionic compounds have high melting and boiling points; are hard, brittle crystalline solids at room temperature; conduct electricity in the liquid state and in solution; and are usually soluble in water.

5. Examples of ionic compounds include sodium chloride, potassium iodide, and calcium chloride. Examples of covalent compounds include water, carbon dioxide, and sucrose.

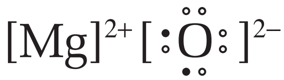
6. Noble gases are unreactive, and most have eight electrons in the valence shell (helium has two). Other elements tend to react so that they attain eight electrons in their valence electron energy level, by gaining, losing, or sharing electrons.

**7. (a)** 

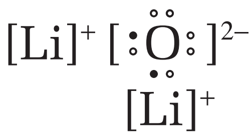
potassium bromide

**(b)** 

calcium fluoride

**(c)** 

magnesium oxide

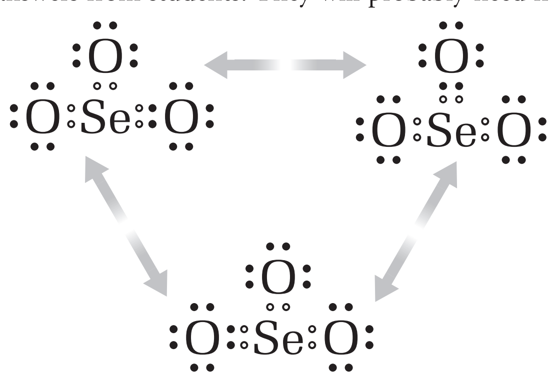
**(d)** 

lithium oxide

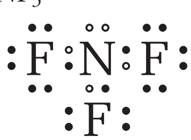
**8. (a)** $SiO_2$ **Note:** $SiO_2$ in nature is a network solid with single Si-O bonds holding the entire crystal together. The mineral is called quartz. Students will answer as follows, however:

**(b)** NaH

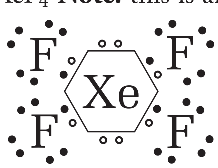
**(c)** $SeO_3$ **Note:** this molecule involves resonance structures. Accept any of these answers from students. They will probably need help with this question.



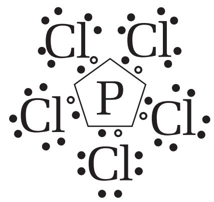
**(d)** $NF_3$



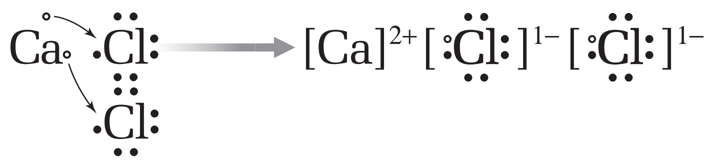
**(e)** $XeF_4$ **Note:** this is an exception to the octet rule.



**(f)** $PCl_5$ **Note:** this is an exception to the octet rule.



**9.** The two electrons transfer, one each to two chlorine atoms forming a calcium ion with a +2 charge and two chloride ions with a −1 charge, resulting in a compound, $CaCl_2$.



**10.** Oxygen, nitrogen and chlorine are gases at room temperature, because they are held together by pure covalent bonds (O=O, N≡N, Cl–Cl). There is little attraction between the molecules because there are no dipoles, thus the molecules remain separate and the elements are gases. Another factor that contributes is the fact that the elements are relatively light, compared to iodine, for example.

**11.** Ionic compounds do not contain molecules, since one ion is bound to several other ions of opposite charge in a lattice. To speak of intermolecular forces in ionic compounds is to imply the existence of molecules in the compounds. It would be better to speak of forces between the ions or interionic forces.

**12.** A covalent bond exists between atoms of the same or almost the same electronegativity. This means that the shared electrons are shared essentially equally between the atoms involved in the bond. In a polar covalent bond, one atom attracts the electrons of the bond more strongly than the other. This results in a charge separation and one side of the bond is more negatively charged than the other, hence a dipole is created across the bond. In terms of electronegativity difference, $\Delta EN$ of 0.5 or less indicates a non-polar covalent bond.

**13.** Atoms joined by an ionic bond have a large electronegativity difference, so that it can be said that one electron (or more) has been transferred from one atom to the other, resulting in the formation of a positive and a negative ion. A polar covalent bond has an electronegativity difference that is large, but the electrons are still thought of as shared; a dipole across the bond results.
A $\Delta EN$ of 1.7 or greater results in an ionic bond, a $\Delta EN$ between 0.5 and 1.7 results in a polar covalent bond.

**14.** **(a)** Mn–N, $\Delta EN = 1.49$; Mn–O, $\Delta EN = 1.89$; Mn–F, $\Delta EN = 2.43$; most polar
**(b)** Be–Br, $\Delta EN = 1.39$; Be–Cl, $\Delta EN = 1.59$; Be–F, $\Delta EN = 2.41$
**(c)** Ag–Cl, $\Delta EN = 1.23$; Hg–Cl, $\Delta EN = 1.26$; Cu–Cl, $\Delta EN = 1.26$; Fe–Cl, $\Delta EN = 1.33$; Ti–Cl, $\Delta EN = 1.62$

**15.** **(a)** a Lewis structure
**(b)** a ball and stick model or a space-filling model
**(c)** a Lewis structure
**(d)** a ball and stick model or a space-filling model

**16.**

| | | |
|---|---|---|
| **(a)** AgCl | $Ag^{1+}$ | $Cl^{1-}$ |
| **(b)** $Mn_3P_2$ | $Mn^2$ | $P^3$ |
| **(c)** $PCl_5$ | $P^5$ | $Cl^1$ |
| **(d)** $CH_4$ | $C^4$ | $H^1$ |
| **(e)** $TiO_2$ | $Ti^{4+}$ | $O^{2-}$ |

(f) $HgF_2$ $Hg^{2+}$ $F^{1-}$
(g) $CaO$ $Ca^{2+}$ $O^{2-}$
(h) $Fe_2S$ $Fe^{2}$ $S^{4}$

17. (a) tin(II) fluoride, $SnF_2$
(b) barium sulfate, $BaSO_4$
(c) hydrogen cyanide, HCN
(d) cesium bromide, CsBr
(e) ammonium hydrogen phosphate, $(NH_4)_2HPO_4$
(f) sodium periodate, $NaIO_4$
(h) potassium bromate, $KBrO_3$
(i) sodium cyanate, NaCNO

18. (a) $HIO_2$, hydrogen iodite (iodous acid)
(b) $KClO_4$, potassium perchlorate
(c) CsF, cesium flouride
(d) $NiCl_2$, nickel(II)chloride, nickelous chloride
(e) $NaHSO_4$, sodium hydrogen sulfate
(f) $Al_2(SO_3)_3$, aluminum sulfite
(g) $K_2Cr_2O_7$, potassium dichromate
(h) $Fe(IO_4)_3$, iron(III)periodate, ferric periodate

19. (a) FeO, iron(II) oxide, ferrous oxide
(b) $SnCl_4$, tin(IV) chloride, stannic chloride
(c) $CuCl_2$, copper(II) chloride, cupric chloride
(d) $CrBr_3$, chromium(III) bromide, chromic bromide
(e) $PbO_2$, lead(IV) oxide, plumbic oxide
(f) HgO, mercury(II) oxide, mercuric oxide

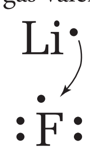
## Inquiry

20. Take the melting point of each substance. The ionic compound should have the higher melting point. Test the electrical conductivity of the melted substance. The ionic material should conduct, the covalent material will not. Test the solubility of the materials in water. If they dissolve in water, test the conductivity of the solution. The ionic
material will conduct electricity in solution, the covalent material will not.

21. Liquid A is polar, since it will move towards a charged rod indicating an opposite charge on one end of the molecule. Liquid B is non-polar since it is unaffected by a charged pod.

## Communication

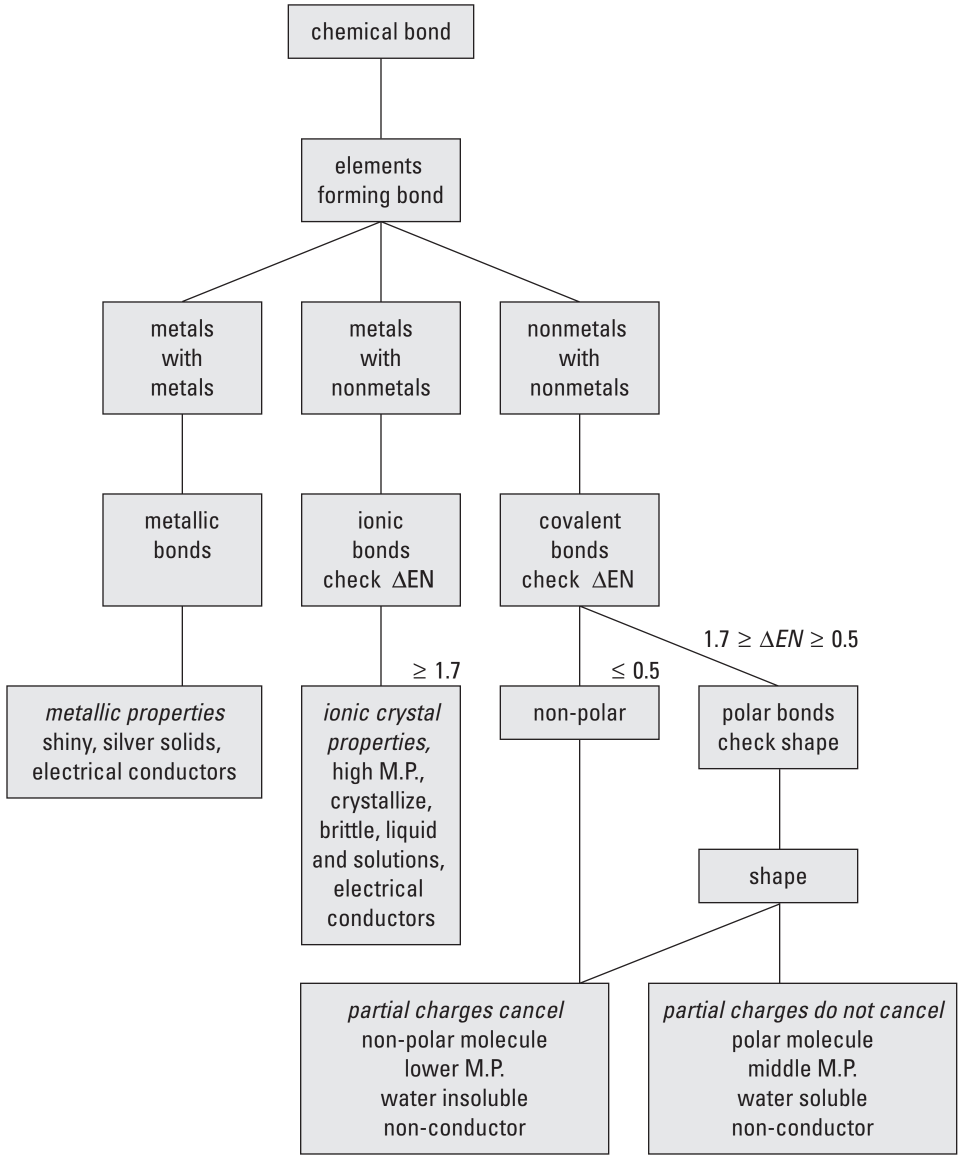
22. Students may answer that the numbers of electrons lost or gained to obtain a noble gas valence shell becomes the valence of the element.




loses 1 electron ∴ valence = +1

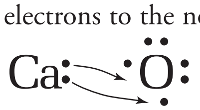
gains 1 electron ∴ valence = –1

**23.** Students may create a concept map like the one shown below:




**24.** Metallic bonds consist of shared electrons, but there are insufficient electrons to fill the valence shell. Hence adding a different metal in any proportion does not disrupt the bonding. No definite ratio need therefore apply to bonding one metal to another. The metal's electrons are very mobile and solid metals can conduct electricity.

Metals bond to non-metals in specific ratios since the non-metal gains a specific number of electrons from the metal, and the metal gives up a specific number of electrons to the non-metal.




Calcium and oxygen bond to give a specific atomic ratio and formula (CaO) to the resulting ionic compound. The ionic solid has its electrons localized to specific ions, so the electrons cannot move to conduct electricity.

**25.** The chemical language system is a universal language. i.e., chemists from all over the world speak the same chemical language. To maintain this universality, chemists worldwide must agree on the naming system.