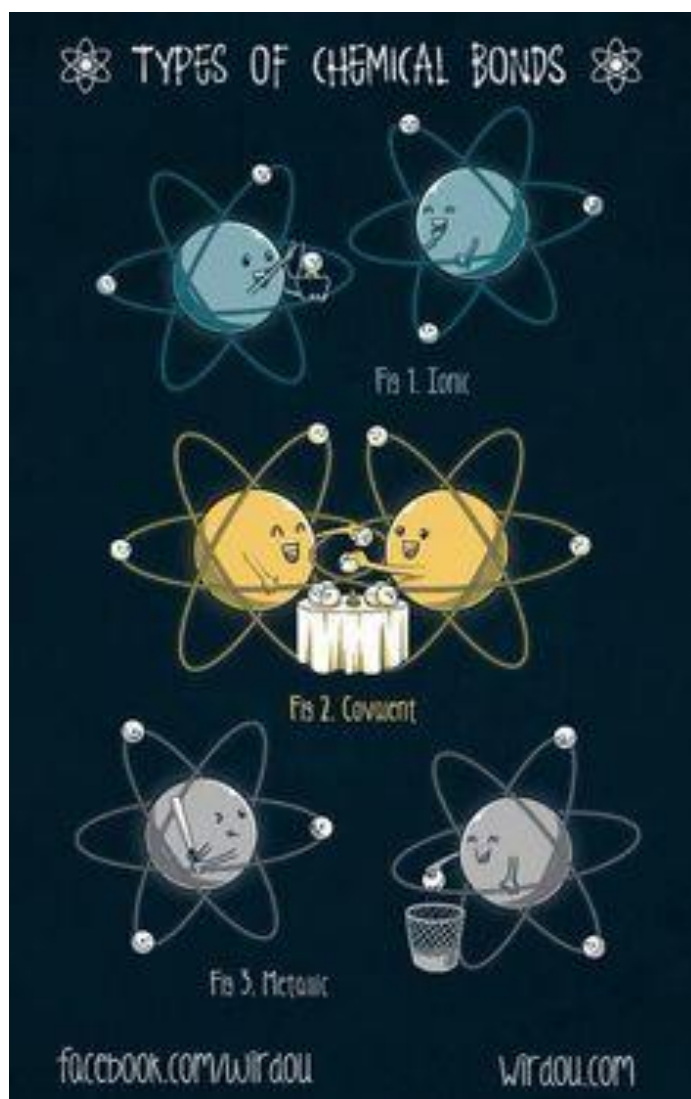


Chemistry 30

Chemical Bonding

For additional help, check out pages 328-438 in Heath Chemistry



Chemical Bonding ANSWER KEY

Ionic Bonds

1. Define the following terms:
 - a) ionic bond – a type of bond between a metal and a non-metal that involves the transfer of electrons to create ions
 - b) crystal – a structure with regular repeating patterns

Reviewing Lewis Dot Diagrams for Ions

Write the Lewis Dot Diagrams for the following:

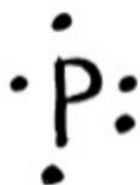
beryllium atom:



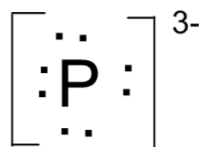
beryllium ion:



phosphorus atom:



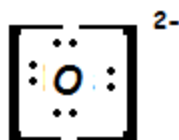
phosphide ion:



oxygen atom:

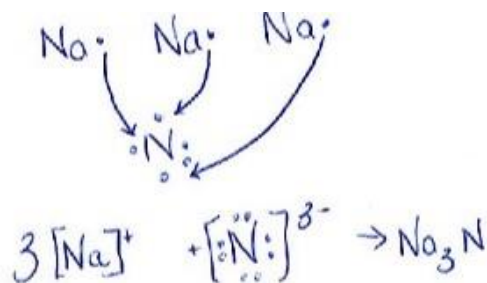


oxide ion:

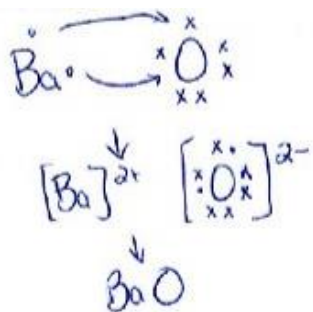


Drawing Ionic Bonds

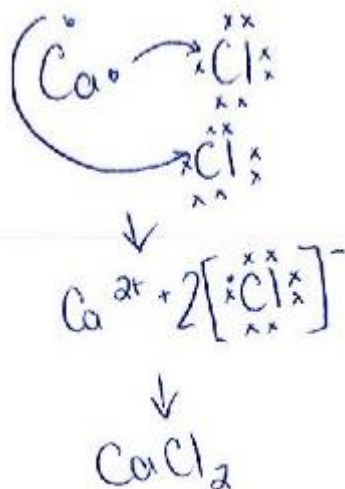
1. sodium nitride



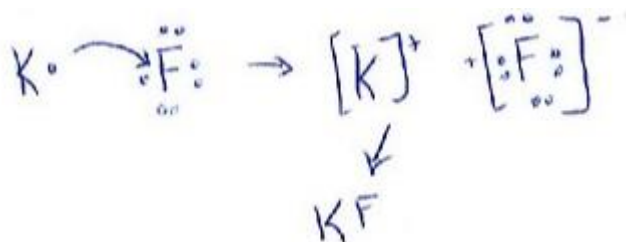
2. barium oxide



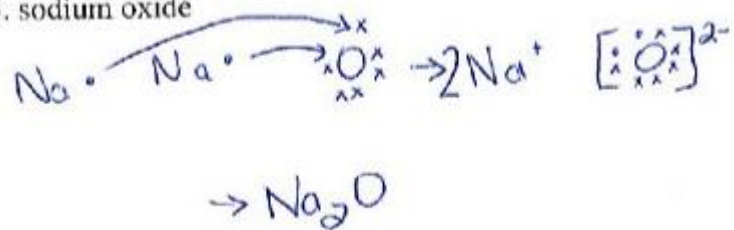
3. calcium chloride



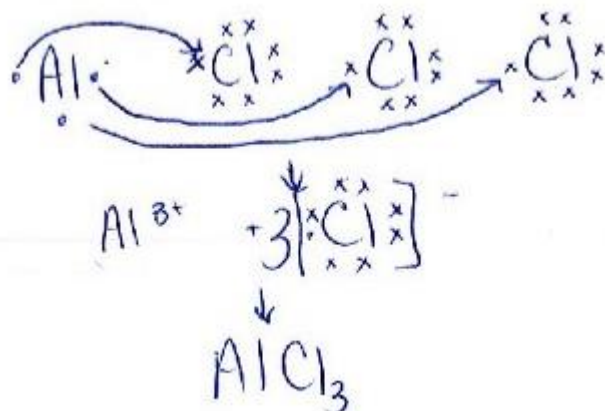
4. potassium fluoride



5. sodium oxide



6. aluminum chloride



Introduction to Covalent Bonds

1. Define the following terms:

- a) covalent bond – a bond formed between two non-metals in which electrons are shared
- b) molecule – a particle that contains two or more atoms that is electrically neutral
- c) intramolecular force– forces inside the molecule that hold the molecule together (ie. Covalent bond)
- d) intermolecular force– forces between molecules that hold one molecule to another

2. Define the following terms:

- a) single covalent – 2 electrons are shared in a covalent bond
- b) double covalent – 4 electrons are shared in a covalent bond
- c) triple covalent – 6 electrons are shared in a covalent bond

3. What type of bonding exists in network solids?

*Covalent bonding exists in network solids within molecules and between molecules.

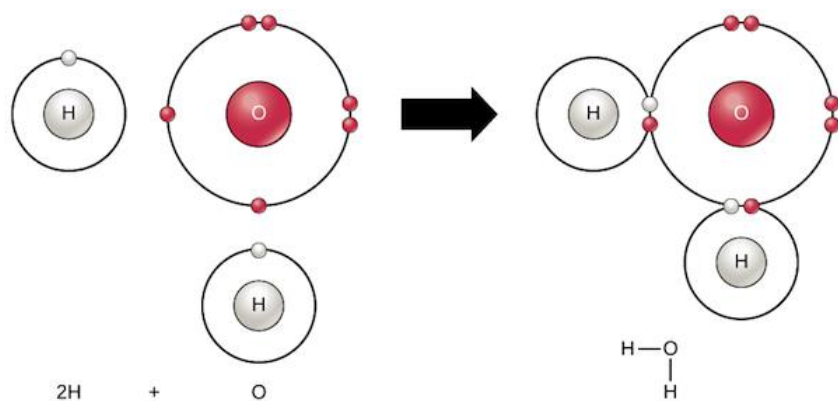
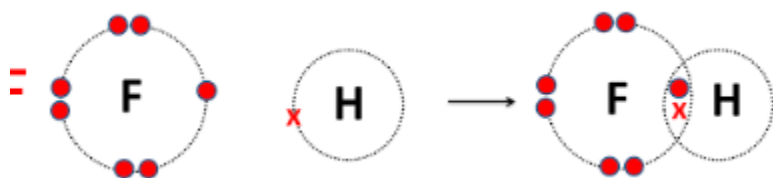
4. List two ways in which a network covalent solid is similar to an ionic compound.

- 1. There are forces between molecules holding them together
- 2. They form a crystalline pattern

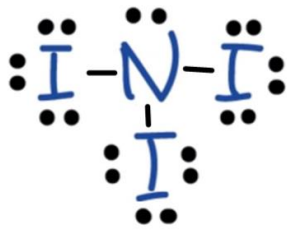
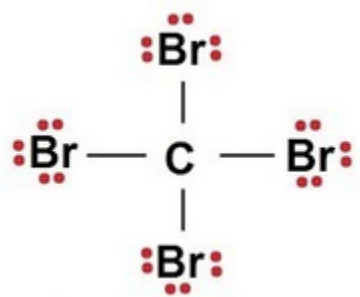
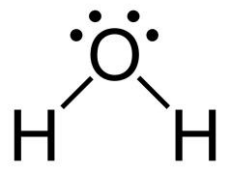
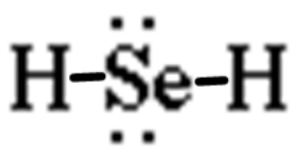
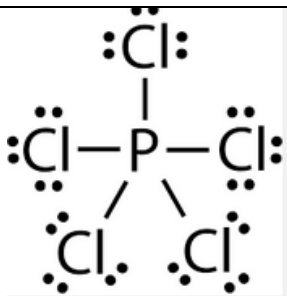
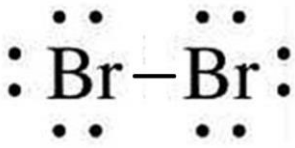
Drawing Covalent Bonds

1. Chlorine and chlorine



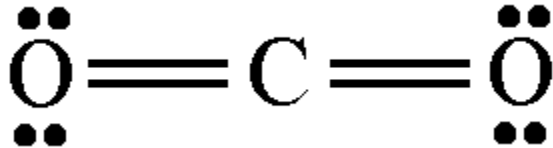
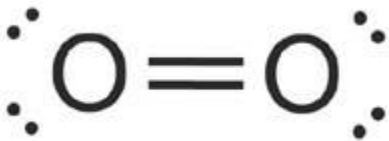
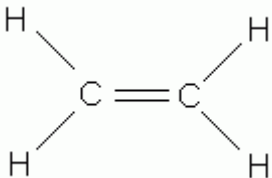
2. Hydrogen and oxygen forming water (H_2O)3. Hydrogen and fluorine (HF)

Drawing Single Covalent Bonds




Work	Final Answer
Ex: nitrogen triiodide (NI_3) $\text{N}(5) + \text{I}(7 \times 3) = 26\text{ve}$	
1. carbon tetrabromide (CBr_4)	
2. dihydrogen monoxide (H_2O)	
3. dihydrogen monoselenide	
4. phosphorus pentachloride	
5. Bromine gas	

Double AND Triple Covalent Bonds

Double bonds can form when a shared single bond alone doesn't satisfy either atoms valence. Double bonds are TWO SHARED PAIRS of electrons for a total of 4 electrons (2 electrons from one atom and 2 from the other). Double bonds are much stronger and bond the atoms closer than a single bond.

Work	Final Answer
Ex: carbon dioxide $C(4) + O(6 \times 2) = 16ve$	
1. Oxygen gas	
2. Ethene (C_2H_4) ** C's are always central and they will link together.	

Triple bonds can form when 3 pairs of electrons are shared for a total of 6 shared electrons. Typically, one atom donates 3 electrons and the other atom donates the other 3. Triple bonds are even stronger than double bonds and the atoms are held even closer together.

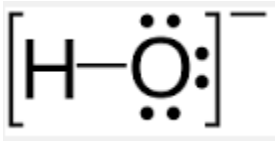
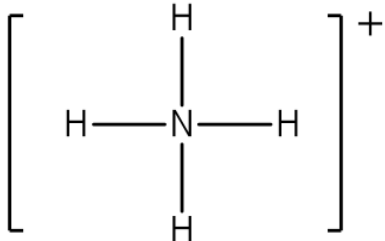
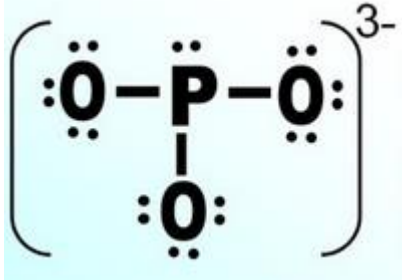
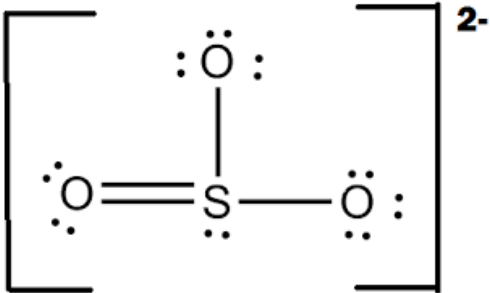
Work	Final Answer
Ex: Nitrogen gas $N(5 \times 2) = 10ve$	
1. Ethyne (C_2H_2) ** C's are always central and they will link together.	
2. hydrogen cyanide (HCN)	

A mixture of all types of bonds: Draw the bonding diagrams (using arrows for ionic and Lewis Structures for covalent).

Work	Final Answer
1. N_2H_2	
2. C_2H_6	
3. CF_2Cl_2	
4. LiF	
5. N_2F_4	
6. Mg_3N_2	<p style="text-align: center;">Magnesium Nitride</p> <p style="text-align: center;">Magnesium loses 2 electrons, and Nitrogen gains 3 electrons to have an Octet.</p> <p style="text-align: center;">$\text{Mg}_3^{+2} \text{N}_2^{-3} = \text{Mg}_3\text{N}_2$</p> <p style="text-align: center;"><small>C. Ophardt, c. 2003</small></p>

Polyatomic Ions

Now you are going to draw electron dot diagrams for the following polyatomic ions. Remember that even though they are ions, the atoms are held together inside the ion with covalent bonds. Negative ions have gained electrons, you must include these in the structure. Positive ions have lost electrons, you must delete these from the structure.

Work	Final Answer
Ex. hydroxide ion $[\text{OH}]^{-1}$ $\text{H}(1) + \text{O}(6) + 1 = 8\text{ve}$	
1. ammonium ion $[\text{NH}_4]^{+1}$	
2. phosphite ion $[\text{PO}_3]^{-3}$	
3. sulfite ion	

Polarity and Electronegativity

1. Define the following terms:

a. polar covalent-**covalent bond with unequal sharing of electrons**

b. nonpolar covalent- **covalent bond with equal sharing of electrons**

1. Sodium chloride (NaCl) is an example of an ionic bond. What is the difference in electronegativity between sodium and chlorine? **A: 2.1**

2. Nitrogen dioxide (NO₂) is an example of a covalent bond. What is the difference in electronegativity between nitrogen and oxygen? **A: 0.5**

3. Use the table and chart from this worksheet to label the following bond types as nonpolar, polar or ionic:

a. NH₃

0.9 difference; therefore, polar covalent

b. MgO

2.3 difference; therefore, ionic

c. Cl₂

0 difference; therefore, nonpolar covalent

d. HCl

0.9 difference; therefore, polar covalent

e. H₂O

1.4 difference; therefore, polar covalent

f. NaCl

2.1 difference; therefore, ionic

g. CH₄

0.4 difference; therefore, non-polar covalent

h. NO₂

0.5 difference; therefore, polar covalent

Metallic Bonds

1. What is a metallic bond? Explain how the ions and electrons are arranged.

A metallic bond is formed between multiple metal atoms with electrons being delocalized between all of the atoms involved.

2. What is an alloy?

An alloy is a mixture of metals that contains metallic bonds.

3. Identify the following compounds as metallic, ionic or covalent:

- | | |
|--|---|
| a. RbCl- ionic | e. Mg_3N_2 - ionic |
| b. Cl_2 - covalent | f. Pt - metallic |
| c. Au - metallic | g. Al - metallic |
| d. $[\text{BrO}_3]^{-1}$ - covalent | h. Ag - metallic |

Intermolecular (van der Waals) Forces

1. List the van der Waals forces in order of increasing strength.

H—bonding > Dipole-Dipole > London Dispersion Forces

2. Explain instantaneous dipoles and how this results in a weak intermolecular force.

Electrons are shared unevenly in a nonpolar bond (momentarily), which causes an unequal distribution in a neighboring molecule...causing a brief attraction between the normally non-polar bonds.

Use your electronegativity table and the chart above to answer the following questions:

1. Determine the INTRAmolecular force for the following compounds: (nonpolar covalent, polar covalent, ionic)

CH_4 = nonpolar covalent	CF_4 = polar covalent	HI = nonpolar covalent
CO_2 = polar covalent	NH_3 = polar covalent	NaCl = ionic

2. Determine the INTERmolecular force for the compounds above: (London forces, dipole-dipole, H bonding, ionic)

CH_4 = London forces	CF_4 = dipole-dipole	HI = London forces
CO_2 = dipole-dipole	NH_3 = H bonding	NaCl = ionic

2.2 Assignment

Bonding Vocabulary Review Sheet

Give the type of bond or force described by the following:

Your choices can be (and you will use some them more than once):

Covalent

Metallic Bond

Network Solid

Ionic bond

Van der Waals

- | | | |
|----------------------|----|---|
| Ionic bond | 1. | This bonding is found between cations and anions. |
| Covalent Bond | 2. | This is found between atoms of nonmetals. |
| Metallic Bond | 3. | This is found between atoms of metals. |
| Network Solid | 4. | This is the force that holds quartz together. |
| Van der Waals | 5. | This is a term to describe all intermolecular forces. |
| Metallic Bond | 6. | This is the force that produces electrical conductivity in the solid state. |
| Ionic bond | 7. | This is the force that produces an electrical insulator in the solid state but an electrical conductor in the liquid state. |
| Ionic bond | 8. | This is the force that holds crystals of table salt together. |
| Network Solid | 9. | This is the force that holds a diamond together. |

Your choices can be (and you will use some them more than once):

Polar Covalent

Hydrogen Bond

London Force

Nonpolar Covalent

Dipole-Dipole Force

Ionic Bond

- | | | |
|----------------------------|-----|--|
| Dipole-Dipole Force | 10. | This is the term to describe the attraction between one polar molecule and another polar molecule. |
| London Force | 11. | This is the term to describe the attraction between one nonpolar molecule and another nonpolar molecule. |
| Nonpolar Covalent | 12. | This is the force inside a molecule of bromine (holds <u>the</u> molecule together). |
| London Force | 13. | This is the force between two molecules of bromine (holds molecules <u>es</u> together). |
| Nonpolar Covalent | 14. | This is the force inside a molecule of methane CH ₄ . |
| London Force | 15. | This is the force between two molecules of methane CH ₄ . |
| Ionic | 16. | This is the force that holds cesium fluoride together. |
| Polar Covalent | 17. | This is the force that holds the carbon to the oxygen in carbon dioxide. |
| Polar Covalent | 18. | This is the force inside a water molecule (H ₂ O) |
| Hydrogen Bond | 19. | This is the force between water molecules. |
| Nonpolar Covalent | 20. | This is the force inside a molecule of nitrogen (N ₂). |

London Force

21. This is the force between two molecules of nitrogen.

22. Explaining the Properties of Ionic Compounds

Using what you know about ionic bonds and crystal structure, complete the following sentence stems.

Ex. Ionic compounds have relatively high melting and boiling points because...their ions are held together by strong forces (ionic bonds).

1. Ionic compounds are hard because ...they have strong intramolecular bonds.
2. A piece of sodium chloride is easily cracked or fractured because...the crystal lattice structure becomes offset when the crystal is hit; this can cause positive ions to be next to each other which would create a repulsive force between like charges-breaking the lattice.
3. Ionic compounds are electrolytes because...the compound dissociates in water and ions (electrons) are able to move freely and can therefore carry an electric charge through the water.

23. Explaining the Properties of Covalent Compounds

Using what you know about covalent bonds, complete the following sentence stems.

Ex. Covalent compounds are usually liquids or gases at room temperature because...there is little attraction between molecules (London dispersion forces)

1. Covalent compounds are share electrons because ...they are made up of non-metals that like to keep their electrons to fill their outer shell (octet rule).
2. A piece of paraffin wax is easily malleable because...there are weak intermolecular forces between the molecules (London Dispersion).
3. Covalent compounds are weak electrolytes because...they don't dissociate in water and the electrons cannot move freely to carry the electric charge.

24. Explaining the Properties of Metallic

Using what you know about metallic bonds, complete the following sentence stems.

Ex. Metallic compounds are malleable and ductile because...metal crystal structures are flexible (layers within the crystal lattice can slide across one another).

1. Metallic compounds conduct electricity because ...delocalized electrons are mobile within the solid.
2. Metallic compounds are insoluble because...this would mean electrons have to be localized to one atom in order to separate the atoms; this is very hard to do and therefore, metals are insoluble.
3. Metallic compounds are usually solid at room temperature because ...metallic bonds are very strong.

25. Bonding Multiple Choice Review Sheet

For questions 1-30 the choices are:

- (1) ionic (2) polar covalent (3) nonpolar covalent (4) metallic (5) van der Waals forces
*** If you use this, be specific on WHICH van der Waals force.

1. The bonding found in calcium chloride is ...1
2. The bonding found in silver is ...4
3. The bonding found inside a molecule of carbon tetrachloride is ...2
4. The bonding that holds water molecules together to make ice is ...5 (H-bonding)
5. The bonding found in a high melting point crystalline solid that conducts electricity when liquid...1
6. The bonding found between atoms in carbon disulfide is ...3
7. The bonding found in a molecule of ammonia (NH₃) is ...2
8. The intramolecular force in iodine (I₂) is ...3
9. The intermolecular force in iodine is ...5 (London Dispersion)
10. The bonding found in sodium fluoride is ...1
13. The bonding that produces electrical conductivity in the solid state is ...4
14. The bonding found in a network solid is either ... or ... 2 or 3
15. The bonding found in any alloy is ...4
16. The bonding that results from the complete transfer of electrons is ...1
17. The bonding that is an equal sharing of valence electrons is ...3
18. The bonding between elements with an electronegativity difference of 1.75 is ...1
19. The bonding within a sulfate ion is ...2
20. The bonding between sodium and sulfate in sodium sulfate is ...1
21. The bonding within hydrocarbon molecules (made of hydrogen and carbon) is ... 3
22. The bonding between hydrocarbon molecules is ...5 (London Dispersion)
23. The bonding that depends upon a loose cloud of valence electrons or an “electron glue” is ...4
24. The bonding that creates dipoles is ...2

For questions 25-35 the choices are:

(1) single covalent (2) double covalent (3) triple covalent (4) hydrogen bonding (5) London forces

25. The bonding that results from the formation of “instantaneous dipoles” is ...5
26. The intramolecular forces in liquid nitrogen (N_2) are ...3
27. The intermolecular forces in liquid nitrogen are ...5
28. Acetylene (C_2H_2) has the carbons bonded to each other and one hydrogen bonded to each carbon. The bonding between the carbon atoms is ...3
29. The attraction of a hydrogen atom in one molecule for a more electronegative element in another molecule is what we call ...4
30. The strongest of the above choices is ...3
31. The weakest of the above choices is ... 5
32. The bonding that is broken when you turn water into steam is ... 4
33. The bonding that is broken when you do electrolysis (splitting) of water molecules to form hydrogen and oxygen is ...1
34. The intramolecular force in hydrogen chloride is ...1
35. The intramolecular force in carbon monoxide is ...3