

TYPES OF CHEMICAL BONDS KEY

- Identify whether each of the following pairs of elements would be expected to form metallic, covalent, or ionic bonds. (This can be done without electronegativities.)
 - carbon and carbon **Covalent** (Both nonmetals)
 - cadmium and cadmium **Metallic** (Pure metal)
 - phosphorus and fluorine **Covalent** (Both nonmetals)
 - molybdenum and selenium **Ionic** (Metal-Nonmetal)
- Identify whether each of the following pairs of elements would be expected to form nonpolar covalent bonds, polar covalent bonds, or ionic bonds. For each of the polar covalent bonds, identify which of the atoms would have the partial negative charge, δ^- , and which atoms would have the partial positive charge, δ^+ . For each ionic bond, indicate which atom would have the positive charge, $+$, and which would have the negative charge, $-$. (This can be done with electronegativities.)
 - potassium and chlorine **Ionic** ($\Delta\text{EN} = 3.16 - 0.82 = 2.34$) **K is +, and Cl is -.**
 - carbon and hydrogen **Nonpolar covalent** ($\Delta\text{EN} = 2.55 - 2.20 = 0.35$)
 - sulfur and oxygen **Polar covalent** ($\Delta\text{EN} = 3.44 - 2.58 = 0.86$) **S is δ^+ , and O is δ^- .**
 - selenium and iodine **Nonpolar covalent** ($\Delta\text{EN} = 2.66 - 2.55 = 0.11$)
- Identify the covalent bond in each pair that would be expected to be most polar. (This can be done with electronegativities.)
 - N-Cl ($\Delta\text{EN} = 3.16 - 3.04 = 0.12$) or N-F ($\Delta\text{EN} = 3.98 - 3.04 = 0.94$)
 - Se-F** ($\Delta\text{EN} = 3.98 - 2.55 = 1.43$) or Se-I ($\Delta\text{EN} = 2.66 - 2.55 = 0.11$)

CHEMICAL BONDING, IONIC CHARGES AND IONIC FORMULAS WORK-SHEET KEY

- Predict whether each of the following would form an ionic bond, a covalent bond, or a metallic bond.
 - Mg and O **ionic**
 - C and Cl **covalent**
 - Ni and Ni **metallic**
- Predict the ionic charges that each of the following would have in an ionic bond.

a. K +1	c. S -2	e. P -3
b. Sr +2	d. Br -1	f. Sc +3
- Write the formula for the ionic compound that would form from the combination of the following elements.

a. Mg and F MgF₂	c. Al and O Al₂O₃
b. Ca and N Ca₃N₂	d. Y and S Y₂S₃

IONIC NOMENCLATURE WORKSHEET KEY

1. Write names that correspond to the following formulas.

- | | |
|---------------------------------|-------------------------------------|
| a. CuF_2 | copper(II) fluoride |
| b. $\text{Al}(\text{CN})_3$ | aluminum cyanide |
| c. NH_4HSO_3 | ammonium hydrogen sulfite |
| d. KHCO_3 | potassium hydrogen carbonate |
| e. $\text{Sr}(\text{ClO})_2$ | strontium hypochlorite |
| f. $\text{Bi}_2(\text{SO}_4)_3$ | bismuth(III) sulfate |

2. Write the formulas that correspond to the following names.

- | | |
|--------------------------------|---|
| a. beryllium bicarbonate | $\text{Be}(\text{HCO}_3)_2$ |
| b. ammonium selenide | $(\text{NH}_4)_2\text{Se}$ |
| c. ferrous oxide | FeO |
| d. scandium permanganate | $\text{Sc}(\text{MnO}_4)_3$ |
| e. mercury(II) chromate | HgCrO_4 |
| f. sodium dihydrogen phosphate | NaH_2PO_4 |
| g. cupric periodate | $\text{Cu}(\text{IO}_4)_2$ |

NOMENCLATURE FOR BINARY COVALENT COMPOUNDS, BINARY ACIDS, AND OXYACIDS KEY

1. Write names that correspond to the following formulas.

- | | | | |
|--------------------------------------|-----------------------------------|------------------------------------|-----------------------------|
| a. H_2SO_3 | sulfurous acid | f. $\text{H}_2\text{S}(\text{aq})$ | hydrosulfuric acid |
| b. $\text{H}_2\text{S}(\text{g})$ | hydrogen sulfide | g. HSO_3^- | hydrogen sulfite ion |
| c. P_2F_4 | diphosphorus tetrafluoride | h. CS_2 | carbon disulfide |
| d. HF | hydrogen fluoride | i. HIO_2 | iodous acid |
| e. $\text{HC}_2\text{H}_3\text{O}_2$ | acetic acid | | |

2. Write the formulas that correspond to the following names.

- | | | | |
|--------------------|--|-----------------------------|--|
| a. perbromic acid | HBrO_4 | d. chromic acid | H_2CrO_4 |
| b. hydroiodic acid | $\text{HI}(\text{aq})$ | e. hydrogen iodide | HI |
| c. silicon dioxide | SiO_2 | f. dinitrogen tetrafluoride | N_2F_4 |

CHEMISTRY 151 - NOMENCLATURE KEY

1. Write formulas that correspond to the following names.

- | | |
|---------------------------------|--|
| a. copper(I) permanganate | CuMnO₄ |
| b. hydrosulfuric acid | H₂S(aq) |
| c. ammonium perbromate | NH₄BrO₄ |
| d. sulfur tetrafluoride | SF₄ |
| e. barium phosphite | Ba₃(PO₃)₂ |
| f. hydrogen iodide | HI |
| g. aluminum bicarbonate | Al(HCO₃)₃ |
| h. ferrous dihydrogen phosphate | Fe(H₂PO₄)₂ |
| i. hypobromous acid | HBrO |
| j. ammonia | NH₃ |

2. Write names that correspond to the following formulas.

- | | |
|---|-----------------------------------|
| a. Hg(CN) ₂ | mercury(II) cyanide |
| b. H ₂ CO ₃ | carbonic acid |
| c. KIO ₂ | potassium iodite |
| d. H ₂ Se (aq) | hydroselenic acid |
| e. Mg(HSO ₃) ₂ | magnesium hydrogen sulfite |
| f. NH ₃ | ammonia |
| g. LiC ₂ H ₃ O ₂ | lithium acetate |
| h. CO | carbon monoxide |
| i. CH ₄ | methane |

Bonding Patterns and Lewis Structures Worksheet Key

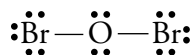
1. What is the most common bonding pattern (number of bonds and number of lone pairs) for the following elements?

- a. H – **1 bond and 0 lone pairs**
- b. iodine – **1 bond and 3 lone pairs**
- c. sulfur – **2 bonds and 2 lone pairs**
- d. N – **3 bonds and 1 lone pair**
- e. C – **4 bonds and 0 lone pairs**
- f. phosphorus – **3 bond and 1 lone pair**
- g. oxygen – **2 bonds and 2 lone pairs**
- h. Br – **1 bond and 3 lone pairs**

2. Draw a Lewis structure for each of the following.

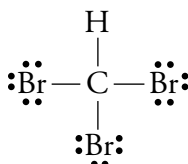
a. oxygen difluoride, OF_2 (an unstable, colorless gas)

Oxygen atoms usually have 2 covalent bonds and 2 lone pairs, and fluorine atoms have 1 covalent bond and 3 lone pairs.



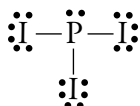
b. bromoform, CHBr_3 (used as a sedative)

Carbon atoms usually have 4 covalent bonds and no lone pairs, hydrogen atoms always have 1 covalent bond and no lone pairs, and bromine atoms usually have 1 covalent bond and 3 lone pairs. The hydrogen atom can be put in any of the 4 positions.



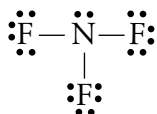
c. phosphorus triiodide, PI_3 (used to make organic compounds)

Phosphorus atoms usually have 3 covalent bonds and 1 lone pair, and iodine atoms usually have 1 covalent bond and 3 lone pairs. The lone pair can be placed in any one of the 4 positions around the phosphorus atom.



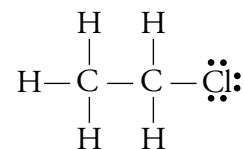
d. nitrogen trifluoride, NF_3 (used in high-energy fuels)

Nitrogen atoms usually have 3 covalent bonds and 1 lone pair, and fluorine atoms have 1 covalent bond and 3 lone pairs. The lone pair can be placed in any one of the 4 positions around the nitrogen atom.



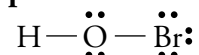
e. chloroethane, $\text{C}_2\text{H}_5\text{Cl}$ (used to make the gasoline additive tetraethyl lead)

Carbon atoms usually have 4 covalent bonds and no lone pairs, hydrogen atoms always have 1 covalent bond and no lone pairs, and chlorine atoms usually have 1 covalent bond and 3 lone pairs. The chlorine atom can be put in any of the 6 positions around the 2 carbon atoms.

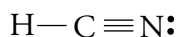


f. hypobromous acid, HOBr (used as a wastewater disinfectant)

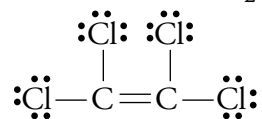
Hydrogen atoms always have 1 covalent bond and no lone pairs, oxygen atoms usually have 2 covalent bonds and 2 lone pairs, and bromine atoms usually have 1 covalent bond and 3 lone pairs.



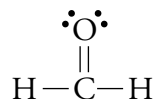
g. hydrogen cyanide, HCN (used to manufacture dyes and pesticides)



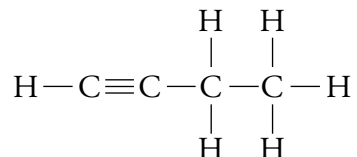
h. tetrachloroethane, C_2Cl_4 (used to make perfumes)



i. formaldehyde, H_2CO (used in embalming fluids)



j. 1-butyne, C_4H_6 (a specialty fuel)



MOLE CALCULATIONS KEY

1. How many moles are in 1.5 pounds of pure sodium carbonate decahydrate, $Na_2CO_3 \cdot 10H_2O$?

$$\begin{aligned} ? \text{ mol } Na_2CO_3 \cdot 10H_2O &= 1.5 \text{ lb } Na_2CO_3 \cdot 10H_2O \left(\frac{453.6 \text{ g}}{1 \text{ lb}} \right) \left(\frac{1 \text{ mol } Na_2CO_3 \cdot 10H_2O}{286.142 \text{ g } Na_2CO_3 \cdot 10H_2O} \right) \\ &= \mathbf{2.4 \text{ mol } Na_2CO_3 \cdot 10H_2O} \end{aligned}$$

2. How many grams of sodium are there in a 2.0 pound box of washing soda that is 85% $Na_2CO_3 \cdot 10H_2O$?

$$\begin{aligned} ? \text{ g Na} &= 2.0 \text{ lb washing soda} \left(\frac{85 \text{ lb } Na_2CO_3 \cdot 10H_2O}{100 \text{ lb washing soda}} \right) \left(\frac{453.6 \text{ g}}{\text{lb}} \right) \left(\frac{1 \text{ mol } Na_2CO_3 \cdot 10H_2O}{286.142 \text{ g } Na_2CO_3 \cdot 10H_2O} \right) \\ &\quad \left(\frac{2 \text{ mol Na}}{1 \text{ mol } Na_2CO_3 \cdot 10H_2O} \right) \left(\frac{22.9898 \text{ g Na}}{1 \text{ mol Na}} \right) \end{aligned}$$

or

$$\begin{aligned} ? \text{ g Na} &= 2.0 \text{ lb washing soda} \left(\frac{85 \text{ lb } Na_2CO_3 \cdot 10H_2O}{100 \text{ lb washing soda}} \right) \left(\frac{453.6 \text{ g}}{\text{lb}} \right) \left(\frac{2 \times 22.9898 \text{ g Na}}{286.142 \text{ g } Na_2CO_3 \cdot 10H_2O} \right) \\ &= \mathbf{1.2 \times 10^2 \text{ g Na}} \end{aligned}$$

3. One source of natural copper is the mineral azurite, $Cu_3(CO_3)_2(OH)_2$. Calculate the maximum mass of copper in kilograms that can be derived from 6.2×10^4 kg of azurite ore that is 7.0% azurite.

$$\begin{aligned} ? \text{ kg Cu} &= 6.2 \times 10^4 \text{ kg ore} \left(\frac{7.0 \text{ kg } Cu_3(CO_3)_2(OH)_2}{100 \text{ kg ore}} \right) \left(\frac{10^3 \text{ g}}{1 \text{ kg}} \right) \left(\frac{1 \text{ mol } Cu_3(CO_3)_2(OH)_2}{344.671 \text{ g } Cu_3(CO_3)_2(OH)_2} \right) \\ &\quad \left(\frac{3 \text{ mol Cu}}{1 \text{ mol } Cu_3(CO_3)_2(OH)_2} \right) \left(\frac{63.546 \text{ g Cu}}{1 \text{ mol Cu}} \right) \left(\frac{1 \text{ kg}}{10^3 \text{ g}} \right) \end{aligned}$$

$$\begin{aligned} \text{or } ? \text{ kg Cu} &= 6.2 \times 10^4 \text{ kg ore} \left(\frac{7.0 \text{ kg } Cu_3(CO_3)_2(OH)_2}{100 \text{ kg ore}} \right) \left(\frac{3 \times 63.546 \text{ kg Cu}}{344.671 \text{ kg } Cu_3(CO_3)_2(OH)_2} \right) \\ &= \mathbf{2.4 \times 10^3 \text{ kg Cu}} \end{aligned}$$

CHEMISTRY 151 - MOLE CALCULATIONS KEY

1. How many moles are there in 75.000 g sulfuric acid?

$$? \text{ mol H}_2\text{SO}_4 = 75.000 \text{ g H}_2\text{SO}_4 \left(\frac{1 \text{ mol H}_2\text{SO}_4}{98.079 \text{ g H}_2\text{SO}_4} \right) = \mathbf{0.76469 \text{ mol H}_2\text{SO}_4}$$

2. Only one isotope of X occurs in nature. One atom of this isotope has a mass of 2.107×10^{-22} g. What is the atomic mass of this element?

$$\frac{? \text{ g}}{\text{mol}} = \frac{2.107 \times 10^{-22} \text{ g}}{1 \text{ atom}} \left(\frac{6.022 \times 10^{23} \text{ atoms}}{1 \text{ mol}} \right) = \mathbf{126.9 \text{ g/mol}}$$

3. Carbon monoxide, CO(g), taken into the lungs reduces the ability of the blood to transport oxygen. It is fatal if its concentration reaches 2.38×10^{-4} g/L. Calculate the number of CO molecules that must be emitted from an automobile exhaust to reach a fatal concentration of CO in a garage with a volume of $1.00 \times 10^5 \text{ ft}^3$.

$$\begin{aligned} ? \text{ CO} &= 1.00 \times 10^5 \text{ ft}^3 \left(\frac{12 \text{ in.}}{1 \text{ ft}} \right)^3 \left(\frac{2.54 \text{ cm}}{1 \text{ in.}} \right)^3 \left(\frac{1 \text{ L}}{10^3 \text{ cm}^3} \right) \left(\frac{2.38 \times 10^{-4} \text{ g CO}}{1 \text{ L}} \right) \left(\frac{6.022 \times 10^{23} \text{ CO}}{28.0105 \text{ g CO}} \right) \\ &= \mathbf{1.45 \times 10^{25} \text{ molecules CO}} \end{aligned}$$

Chemistry 151

Worksheet Conversion Between Mass of Element and Mass of Compound Key

1. What is the maximum mass of phosphorus that can be obtained from 15.042 g tetraphosphorus hexoxide?

$$? \text{ g P} = 15.042 \text{ g P}_4\text{O}_6 \left(\frac{1 \text{ mol P}_4\text{O}_6}{219.8916 \text{ g P}_4\text{O}_6} \right) \left(\frac{4 \text{ mol P}}{1 \text{ mol P}_4\text{O}_6} \right) \left(\frac{30.9738 \text{ g P}}{1 \text{ mol P}} \right) = \mathbf{8.4752 \text{ g P}}$$

$$\text{or } ? \text{ g P} = 15.042 \text{ g P}_4\text{O}_6 \left(\frac{4 \times 30.9738 \text{ g P}}{219.8916 \text{ g P}_4\text{O}_6} \right) = \mathbf{8.4752 \text{ g P}}$$

2. The mineral hematite is iron(III) oxide. Hematite ore contains unwanted material called gangue, in addition to the iron(III) oxide. If 5.000 kg of ore contains 2.7845 kg of iron, what percentage of the ore is iron(III) oxide?

$$\begin{aligned} \% \text{ Fe}_2\text{O}_3 &= \frac{? \text{ kg Fe}_2\text{O}_3}{? \text{ kg ore}} \times 100 \\ &= \frac{2.7845 \text{ kg Fe}}{5.000 \text{ kg ore}} \left(\frac{10^3 \text{ g}}{1 \text{ kg}} \right) \left(\frac{1 \text{ mol Fe}}{55.847 \text{ g Fe}} \right) \left(\frac{1 \text{ mol Fe}_2\text{O}_3}{2 \text{ mol Fe}} \right) \left(\frac{159.692 \text{ g Fe}_2\text{O}_3}{1 \text{ mol Fe}_2\text{O}_3} \right) \left(\frac{1 \text{ kg}}{10^3 \text{ g}} \right) \times 100 \end{aligned}$$

$$\text{or } \% \text{ Fe}_2\text{O}_3 = \frac{? \text{ kg Fe}_2\text{O}_3}{? \text{ kg ore}} \times 100 = \frac{2.7845 \text{ kg Fe}}{5.000 \text{ kg ore}} \left(\frac{159.692 \text{ kg Fe}_2\text{O}_3}{2 \times 55.847 \text{ kg Fe}} \right) \times 100 = \mathbf{79.62\% \text{ Fe}_2\text{O}_3}$$

3. Chloromycetin is an antibiotic with the formula $\text{C}_{11}\text{H}_{12}\text{O}_5\text{N}_2\text{Cl}_2$. A 1.03 g sample of an ophthalmic ointment containing chloromycetin was chemically treated to convert its chlorine to chloride, Cl^- . The chloride was precipitated as AgCl , which weighed 0.0129 g. What is the percent chloromycetin in the ointment?

$$\begin{aligned} \% \text{ chl.} &= \frac{? \text{ g C}_{11}\text{H}_{12}\text{O}_5\text{N}_2\text{Cl}_2}{? \text{ g oint}} \times 100 = \frac{0.0129 \text{ g AgCl}}{1.03 \text{ g oint.}} \left(\frac{1 \text{ mol AgCl}}{143.321 \text{ g AgCl}} \right) \left(\frac{1 \text{ mol Cl}}{1 \text{ mol AgCl}} \right) \\ &\quad \left(\frac{1 \text{ mol C}_{11}\text{H}_{12}\text{O}_5\text{N}_2\text{Cl}_2}{2 \text{ mol Cl}} \right) \left(\frac{323.13 \text{ g C}_{11}\text{H}_{12}\text{O}_5\text{N}_2\text{Cl}_2}{1 \text{ mol C}_{11}\text{H}_{12}\text{O}_5\text{N}_2\text{Cl}_2} \right) \times 100 = \mathbf{1.41\% \text{ chl.}} \end{aligned}$$

Particles and Types of Attractions Worksheet Key

For each of the following, write the name for the type of particle viewed as forming the structure of a solid, liquid, or gas (e.g. atoms, ions, or molecules), and write the name of the type of attraction holding these particles in the solid and liquid form (covalent bonds, ionic bonds, metallic bonds, hydrogen bonds, dipole-dipole attractions, or London forces).

Substance	Particles to Visualize	Type of Attraction
a. Silver	Cations in a sea of electrons	Metallic bonds
b. HCl	Molecules	Dipole-dipole attractions
c. C ₂ H ₅ OH	Molecules	Hydrogen bonds
d. I ₂	Molecules	London forces
e. NaBr	Cations and anions	Ionic bonds
f. Carbon (diamond)	Atoms	Covalent bonds
g. C ₅ H ₁₂	Molecules	London forces
h. water	Molecules	Hydrogen bonds

Alkane Nomenclature Worksheet Key

Complete the following table by either drawing the name that corresponds to the Lewis structure given or the Lewis structure for the name given.

Name	Lewis structure
a. hexane	$ \begin{array}{cccccc} \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} \\ & & & & & \\ \text{H}-\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{C}-\text{H} \\ & & & & & \\ \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} \end{array} $
b. butane	$ \begin{array}{cccc} \text{H} & \text{H} & \text{H} & \text{H} \\ & & & \\ \text{H}-\text{C} & -\text{C} & -\text{C} & -\text{C}-\text{H} \\ & & & \\ \text{H} & \text{H} & \text{H} & \text{H} \end{array} $
c. methylbutane	$ \begin{array}{cccc} & & \text{H} & \\ & & & \\ & & \text{H}-\text{C}-\text{H} & \\ & & & \\ \text{H} & & \text{H} & \text{H} \\ & & & \\ \text{H}-\text{C} & -\text{C} & -\text{C} & -\text{C}-\text{H} \\ & & & \\ \text{H} & \text{H} & \text{H} & \text{H} \end{array} $
d. 2,4-dimethylhexane	$ \begin{array}{cccccc} & & & & \text{H} & \\ & & & & & \\ & & & & \text{H}-\text{C}-\text{H} & \\ & & & & & \\ \text{H} & \text{H} & \text{H} & \text{H} & & \text{H} \\ & & & & & \\ \text{H}-\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{C}-\text{H} \\ & & & & & \\ \text{H} & \text{H} & & \text{H} & \text{H} & \text{H} \\ & & \text{H}-\text{C}-\text{H} & & & \\ & & & & & \\ & & \text{H} & & & \end{array} $
e. 4-isopropyloctane	$ \begin{array}{cccccccc} \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} \\ & & & & & & & \\ \text{H}-\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{C}-\text{H} \\ & & & & & & & \\ \text{H} & \text{H} & \text{H} & \text{H} & & \text{H} & \text{H} & \text{H} \\ & & & & \text{H} & & \text{H} & \\ & & & & & & & \\ & & & & \text{H}-\text{C} & -\text{C} & -\text{C}-\text{H} & \\ & & & & & & & \\ & & & & \text{H} & \text{H} & \text{H} & \end{array} $