

## Chapter 3 Exercise Key

**Exercise 3.1 – Classifying Compounds:** Classify each of the following substances as either a molecular compound or an ionic compound.

- a. formaldehyde,  $\text{CH}_2\text{O}$  (used in embalming fluids)

**all nonmetal atoms - molecular**

- b. magnesium chloride,  $\text{MgCl}_2$  (used in fireproofing wood and in paper manufacturing)

**metal-nonmetal - ionic**

**Exercise 3.2 – Electronegativities and Bond Type:** Classify the following bonds as nonpolar covalent, polar covalent, or ionic. If a bond is polar covalent, identify which atom has the partial negative charge and which has the partial positive charge. If a bond is ionic, identify which atom has the negative charge and which has the positive charge.

- a. N bonded to H **polar covalent**

**N is partial negative and H is partial positive.**

- b. N bonded to Cl **nonpolar covalent**

- c. Ca bonded to O **ionic**

**O is negative, and Ca is positive.**

- d. P bonded to F **polar covalent**

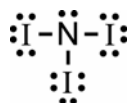
**N is partial negative and H is partial positive.**

**Exercise 3.3 – Electronegativities and Bond Polarity:** Which bond would you expect to be more polar, P–Cl or P–F?

**Exercise 3.4 - Drawing Lewis Structures from Formulas:** Draw a Lewis structure for each of the following formulas:

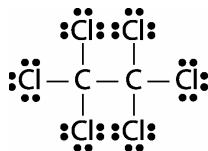
- a. nitrogen triiodide,  $\text{NI}_3$  (explodes at the slightest touch)

Nitrogen atoms usually have 3 covalent bonds and 1 lone pair, and iodine atoms usually have 1 covalent bond and 3 lone pairs.



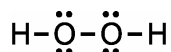
- b. hexachloroethane,  $C_2Cl_6$  (used to make explosives)

Carbon atoms usually have 4 covalent bonds and no lone pairs, and chlorine atoms usually have 1 covalent bond and 3 lone pairs.



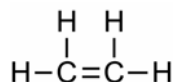
- c. hydrogen peroxide,  $H_2O_2$  (a common antiseptic)

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



- d. ethylene (or ethene),  $C_2H_4$  (used to make polyethylene)

Carbon atoms form 4 bonds with no lone pairs, and hydrogen atoms form 1 bond with no lone pairs. To achieve these bonding patterns, there must be a double bond between the carbon atoms.



**Exercise 3.5 - Naming Binary Covalent Compounds:** Write names that correspond to the following formulas:

- $P_2O_5$  **diphosphorus pentoxide**
- $PCl_3$  **phosphorus trichloride**
- $CO$  **carbon monoxide**
- $H_2S$  **dihydrogen monosulfide or hydrogen sulfide**
- $NH_3$  **ammonia**

**Exercise 3.6 - Writing Formulas for Binary Covalent Compounds:** Write formulas that correspond to the following names:

- disulfur decafluoride  **$S_2F_{10}$**
- nitrogen trifluoride  **$NF_3$**
- propane  **$C_3H_8$**
- hydrogen chloride  **$HCl$**

**Exercise 3.7 - Naming Monatomic Ions:** Write names that correspond to the following formulas for monatomic ions:

- $Mg^{2+}$  **magnesium ion**
- $F^-$  **fluoride ion**
- $Sn^{2+}$  **tin(II) ion**



**Exercise 3.11 – Nomenclature, Formulas to Names:** Write names that correspond to the following formulas.

Formula	Name
$P_2O_5$	<b>diphosphorus pentoxide</b>
$PCl_3$	<b>phosphorus trichloride</b>
$CO$	<b>carbon monoxide</b>
$H_2S(g)$	<b>dihydrogen monosulfide or hydrogen sulfide</b>
$H_2S(aq)$	<b>hydrosulfuric acid</b>
$NH_3$	<b>ammonia</b>
$H_3PO_4$	<b>phosphoric acid</b>
$H_3PO_3$	<b>phosphorus acid</b>
$H_3PO_2$	<b>hypophosphorous acid</b>
$CH_3OH$	<b>methanol</b>
$C_{12}H_{22}O_{11}$	<b>sucrose</b>

**Exercise 3.12 - Nomenclature, Names to Formulas:** Write formulas that correspond to the following names.

Name	Formula
disulfur decafluoride	<b><math>S_2F_{10}</math></b>
nitrogen trifluoride	<b><math>NF_3</math></b>
butane	<b><math>C_4H_{10}</math></b>
hydrogen chloride	<b><math>HCl</math></b>
hydrochloric acid	<b><math>HCl(aq)</math></b>
carbonic acid	<b><math>H_2CO_3</math></b>
periodic acid	<b><math>HIO_4</math></b>
ethanol or ethyl alcohol	<b><math>C_2H_5OH</math></b>
glucose	<b><math>C_6H_{12}O_6</math></b>

**Exercise 3.13 – Types of Particles and Attractions:** Complete the following table by (1) writing the name for the type of particle viewed as forming the structure of a solid, liquid, or gas of each of the following substances and (2) writing the name of the type of attraction holding these particles in the solid and liquid form.

<b>Substance</b>	<b>Particles to Visualize</b>	<b>Type of Attraction</b>
iron	<b>Fe cations in a sea of electrons</b>	<b>Metallic Bonds</b>
MgO	<b>Mg<sup>2+</sup> cations and O<sup>2-</sup> anions</b>	<b>Ionic Bonds</b>
iodine	<b>I<sub>2</sub> molecules</b>	<b>London forces</b>
CH <sub>3</sub> OH	<b>CH<sub>3</sub>OH molecules</b>	<b>Hydrogen Bonds</b>
NH <sub>3</sub>	<b>NH<sub>3</sub> molecules</b>	<b>Hydrogen Bonds</b>
hydrogen chloride	<b>HCl molecules</b>	<b>Dipole-Dipole Attractions</b>
C (diamond)	<b>Carbon atoms</b>	<b>Covalent bonds</b>
lithium sulfate	<b>Li<sup>+</sup> cations and SO<sub>4</sub><sup>2-</sup> anions</b>	<b>Ionic Bonds</b>

**Exercise 3.14 – Element Molar Mass Calculations:** An analysis of the element lithium shows that it is composed of two isotopes. 7.5% of the lithium atoms are lithium-6, and 92.5% are lithium-7. Each atom of lithium-6 has a mass of 6.0151214 u, and each atom of lithium-7 has a mass of 7.0160030 u.

- a. What is the atomic mass of lithium? (Report your answer to the third decimal position,  $\pm 0.001$ .)

$$\text{Atomic mass} = \sum_{\text{isotope}}^{\text{each}} (\text{decimal fraction of isotope})(\text{mass of isotope})$$

$$\text{decimal fraction of isotope} = \frac{\text{percent abundance}}{100}$$

$$\begin{aligned} \text{Atomic mass} &= 0.075 (6.0151214 \text{ u}) + 0.925 (7.0160030 \text{ u}) \\ &= \mathbf{6.941 \text{ u}} \end{aligned}$$

- b. Write a conversion factor that will convert between grams of the element lithium and moles of lithium.

$$\left( \frac{\mathbf{6.941 \text{ g Li}}}{\mathbf{1 \text{ mole Li}}} \right)$$

- d. How many moles of lithium are in a sample of lithium that has a mass of 7.249 pounds?

$$? \text{ moles Li} = 7.249 \text{ lb Li} \left( \frac{453.6 \text{ g}}{1 \text{ lb}} \right) \left( \frac{1 \text{ mole Li}}{6.941 \text{ g Li}} \right) = \mathbf{473.7 \text{ moles L}}$$

**Exercise 3.15 – Element Molar Mass Calculations:** Gold is often sold in units of troy ounces. (To four significant figures, there are 31.10 grams per troy ounce.) How many moles of gold, Au, are there is 1.00 troy ounce of pure gold?

$$\begin{aligned} ? \text{ mole Au} &= 1.00 \text{ troy oz Au} \left( \frac{31.10 \text{ g}}{1 \text{ troy oz}} \right) \left( \frac{1 \text{ mole Au}}{196.9665 \text{ g Au}} \right) \\ &= \mathbf{0.158 \text{ mole Au}} \end{aligned}$$

**Exercise 3.16 – Molar Mass for Molecular Compounds:** A typical 6.0 fluid ounce glass of wine contains about 16 g of ethanol,  $C_2H_5OH$ .

- a. What is the molecular mass of  $C_2H_5OH$ ?

$$2(12.011) + 6(1.00794) + 1(15.9994) = \mathbf{46.069}$$

- b. Write a conversion factor that will convert between mass and moles of  $C_2H_5OH$ .

$$\left( \frac{\mathbf{46.069 \text{ g } C_2H_5OH}}{\mathbf{1 \text{ mol } C_2H_5OH}} \right)$$

- e. What is the volume in milliliters of 1.0 mole of pure  $C_2H_5OH$ ? (The density of ethanol is 0.7893 g/mL.)

$$\begin{aligned} ? \text{ mL } C_2H_5OH &= 1.0 \text{ mol } C_2H_5OH \left( \frac{46.069 \text{ g } C_2H_5OH}{1 \text{ mol } C_2H_5OH} \right) \left( \frac{1 \text{ mL } C_2H_5OH}{0.7893 \text{ g } C_2H_5OH} \right) \\ &= \mathbf{58 \text{ mL } C_2H_5OH} \end{aligned}$$

**Exercise 3.17 – Molar Mass for Ionic Compounds:** A quarter teaspoon of a typical baking powder contains about 0.4 g of sodium hydrogen carbonate,  $NaHCO_3$ , which is often called bicarbonate of soda.

- a. Calculate the formula mass of sodium hydrogen carbonate.

$$\begin{aligned} \text{Formula Mass} &= 1(22.9898) + 1(1.00794) + 1(12.011) + 3(15.9994) \\ &= \mathbf{84.007} \end{aligned}$$

- b. Write a conversion factor that could be used to convert between mass and moles of  $NaHCO_3$ .

$$\left( \frac{\mathbf{84.007 \text{ g } NaHCO_3}}{\mathbf{1 \text{ mol } NaHCO_3}} \right)$$

- c. How many moles of  $NaHCO_3$  are there is 0.4 g of  $NaHCO_3$ ?

$$? \text{ mol } NaHCO_3 = 0.4 \text{ g } NaHCO_3 \left( \frac{1 \text{ mol } NaHCO_3}{84.007 \text{ g } NaHCO_3} \right) = \mathbf{0.005 \text{ mol } NaHCO_3}$$

**Exercise 3.18 – Conversion Between Amount of Element and Amount of Compound:** Disulfur dichloride,  $S_2Cl_2$ , is used in vulcanizing rubber and hardening soft woods. It can be made from the reaction of pure sulfur with chlorine gas. What is the mass of  $S_2Cl_2$  that contains 1.238 kg S?

$$? \text{ kg } S_2Cl_2 = 1.238 \text{ kg S} \left( \frac{10^3 \text{ g}}{1 \text{ kg}} \right) \left( \frac{1 \text{ mole S}}{32.066 \text{ g S}} \right) \left( \frac{1 \text{ mole } S_2Cl_2}{2 \text{ mole S}} \right) \left( \frac{135.037 \text{ g } S_2Cl_2}{1 \text{ mole } S_2Cl_2} \right) \left( \frac{1 \text{ kg}}{10^3 \text{ g}} \right)$$

$$\text{or } ? \text{ kg } S_2Cl_2 = 1.238 \text{ kg S} \left( \frac{135.037 \text{ kg } S_2Cl_2}{2 \times 32.066 \text{ kg S}} \right) = \mathbf{2.607 \text{ kg } S_2Cl_2}$$

**Exercise 3.19 – Conversion Between Amount of Element and Amount of**

**Compound:** Vanadium metal, used as a catalyst and to make steel, is produced from the reaction of vanadium(V) oxide,  $V_2O_5$ , and calcium metal. What is the mass in kilograms of vanadium in 2.3 metric tons of  $V_2O_5$ ?

$$? \text{ kg V} = 2.3 \text{ met. tons } V_2O_5 \left( \frac{10^3 \text{ kg}}{1 \text{ met. ton}} \right) \left( \frac{10^3 \text{ g}}{1 \text{ kg}} \right) \left( \frac{1 \text{ mole } V_2O_5}{181.880 \text{ g } V_2O_5} \right) \left( \frac{2 \text{ mole V}}{1 \text{ mole } V_2O_5} \right) \left( \frac{50.9415 \text{ g V}}{1 \text{ mole V}} \right) \left( \frac{1 \text{ kg}}{10^3 \text{ g}} \right)$$

$$\begin{aligned} \text{or } ? \text{ kg V} &= 2.3 \text{ met. tons } V_2O_5 \left( \frac{2 \times 50.9415 \text{ met. tons V}}{181.880 \text{ met. tons } V_2O_5} \right) \left( \frac{10^3 \text{ kg}}{1 \text{ met. ton}} \right) \\ &= \mathbf{1.3 \times 10^3 \text{ kg V}} \end{aligned}$$

**Exercise 3.20 – Conversion Between Amount of Element and Amount of**

**Compound:** Calamine has two definitions. It is a naturally occurring zinc silicate that has the equivalent of 67.5% zinc oxide,  $ZnO$ , and it is a substance that is used to make the calamine lotion. The naturally occurring calamine is used to make zinc metal. What is the mass in kilograms of zinc in  $1.347 \times 10^4$  kg of natural calamine that is 67.5%  $ZnO$ ?

$$? \text{ kg Zn} = 1.347 \times 10^4 \text{ kg calamine} \left( \frac{67.5 \text{ kg ZnO}}{100 \text{ kg calamine}} \right) \left( \frac{10^3 \text{ g}}{1 \text{ kg}} \right) \left( \frac{1 \text{ mole ZnO}}{81.39 \text{ g ZnO}} \right) \left( \frac{1 \text{ mole Zn}}{1 \text{ mole ZnO}} \right) \left( \frac{65.39 \text{ g Zn}}{1 \text{ mole Zn}} \right) \left( \frac{1 \text{ kg}}{10^3 \text{ g}} \right)$$

$$\begin{aligned} \text{or } ? \text{ kg Zn} &= 1.347 \times 10^4 \text{ kg calamine} \left( \frac{67.5 \text{ kg ZnO}}{100 \text{ kg calamine}} \right) \left( \frac{1 \times 65.39 \text{ kg Zn}}{81.39 \text{ kg ZnO}} \right) \\ &= \mathbf{7.30 \times 10^3 \text{ kg Zn}} \end{aligned}$$