Unit 6 → Types of Compounds

Vocabulary

anion	cation	chemical bond
electrolyte	formula unit	ionic bond
lattice energy	monatomic ion	oxidation number
oxyanion	polyatomic ion	coordinate covalent bond
covalent bond	endothermic	exothermic
hybridization	Lewis structure	molecule
oxyacid	pi bond	polar covalent
resonance	sigma bond	structural formula
VSEPR model		

Objectives

- **Define** chemical bond.
- **Relate** chemical bond formation to electron configuration.
- **Describe** the formation of positive and negative ions.
- **Describe** the formation of ionic bonds.
- **Account** for many of the physical properties of an ionic compound.
- **Discuss** the energy involved in the formation of an ionic bond.
- **Write** formulas for ionic compounds and oxyanions.
- **Name** ionic compounds and oxyanions.
- **Apply** the octet rule to atoms that bond covalently.
- **Describe** the formation of single, double, and triple covalent bonds.
- **Compare** and **contrast** sigma and pi bonds.
- **Relate** the strength of covalent bonds to bond length and bond dissociation energy.
- **Identify** the names of binary molecular compounds from their formulas.
- **Name** acidic solutions.
- **List** five basic steps used in drawing Lewis structures.
- **Explain** why resonance occurs, and **identify** resonance structures.
- **Explain** the octet rule, and **identify** molecules in which these exceptions occur.
- **Discuss** the VSEPR bonding theory.
- **Predict** the shape of and the bond angles in a molecule.
- **Define** hybridization.
- **Describe** how electronegativity is used to determine bond type.
- **Compare** and **contrast** polar and nonpolar covalent bonds and polar and nonpolar molecules.
- **Describe** the characteristics of compounds that are covalently bonded.

Short Answer and Problem-Solving

1. Name the following substances.

   H_2SO_4 Sulfuric Acid AgCl Silver chloride

   $CuNO_3$ Copper I Nitrate $Ca(OH)_2$ calcium hydroxide

2. Write the formulas for the following compounds.

   hydrofluoric acid HF diphosphorus pentoxide P_2O_5

   iron(III) oxide Fe_2O_3 aluminum chloride $AlCl_3$

Unit 7 → Chemical Reactions

Vocabulary

aqueous solution	chemical equation	chemical reaction
coefficient	combustion reaction	complete ionic equation
decomposition reaction	double replacement reaction	net ionic equation
precipitate	product	reactant
single replacement reaction	solute	solvent
spectator ion	synthesis reaction	

Objectives

- **Recognize** evidence of chemical change.
- **Represent** chemical reactions with equations.
- **Classify** chemical reactions.
- **Identify** the characteristics of different classes of chemical reactions.
- **Describe** aqueous solutions.
- **Write** complete ionic and net ionic equations for chemical reactions in aqueous solutions.
- **Predict** whether reactions in aqueous solutions will produce a precipitate, water, or a gas.

Short Answer and Problem-Solving

3. Balance and identify the type of reaction for the following using the following symbols: (s) synthesis, (c) combustion, (d) decomposition, (sr) single replacement, (dr) double replacement.

$\_\_\_\_I_2 + \_2\_ NaF \rightarrow \_2\_ NaI + \_\_\_\_F_2$	SR
$\_\_\_\_KOH + \_\_\_\_AgNO_3 \rightarrow \_\_\_\_KNO_3 + \_\_\_\_AgOH$	DR
$\_\_\_\_C_3H_8 + \_5\_ O_2 \rightarrow \_3\_ CO_2 + \_4\_ H_2O$	C
$\_3\_ H_2 + \_\_\_\_N_2 \rightarrow \_2\_ NH_3$	S
$\_\_\_\_(NH_4)_2SO_4 \rightarrow \_2\_ NH_3 + \_\_\_\_H_2SO_4$	D

4. Predict the products of the following reactions.

$CH_4 + O_2 \rightarrow$ $CO_2 + H_2O$

$Al + Pb(NO_3)_2 \rightarrow$ $Al(NO_3)_3 + Pb$

$Ca(OH)_2 + HCl \rightarrow$ $CaCl_2 + H_2O$

$PbO_2 \rightarrow$ $Pb + O_2$

$Na + Cl_2 \rightarrow$ $NaCl$

Unit 8 → Chemical Quantities

Vocabulary

Avogadro's number	empirical formula	molar mass
mole	molecular formula	percent composition
actual yield	excess reactant	limiting reactant
mole ratio	percent yield	stoichiometry
theoretical yeild		

Objectives

- **Describe** how a mole is used in chemistry.
- **Relate** a mole to common counting units.
- **Convert** moles to number of representative particles and number of representative particles to moles.
- **Relate** the mass of an atom to the mass of a mole of atoms.
- **Calculate** the number of moles in a given mass of an element and the mass of a given number of moles of an element.
- **Calculate** the number of moles of an element when given the number of atoms of the element.
- **Recognize** the mole relationships shown by a chemical formula.
- **Calculate** the molar mass of a compound.
- **Calculate** the number of moles of a compound from a given mass of the compound, and the mass of a compound from a given number of moles of the compound.
- **Determine** the number of atoms or ions in a mass of a compound.
- **Explain** what is meant by the percent composition of a compound.
- **Determine** the empirical and molecular formulas for a compound from mass percent and actual mass data.
- **Identify** the quantitative relationships in a balanced chemical equation.
- **Determine** the mole ratios from a balanced chemical equation.
- **Explain** the sequence of steps used in solving stoichiometric problems.
- **Use** the steps to solve stoichiometric problems.
- **Identify** the limiting reactant in a chemical equation.
- **Identify** the excess reactant and calculate the amount of remaining after the reaction is complete.
- **Calculate** the mass of a product when the amounts of more than one reactant are given.
- **Calculate** the theoretical yield of a chemical reaction from data.
- **Determine** the percent yield for a chemical reaction.

Short Answer and Problem-Solving

5. Calculate the number of molecules in 87 grams of hydrochloric acid.

$$87\text{g HCl}\left(\frac{1\text{mol}}{36\text{g}}\right)\left(\frac{6.02\times10^{23}\text{ molecules}}{1\text{mol}}\right) = 1.5\times10^{24}\text{ molecules}$$

6. Calculate the number of grams of $KClO_3$ in 1.26×10^{37} molecules of the compound.

$$1.26\times10^{37}\text{ molecules}\left(\frac{1\text{mol}}{6.02\times10^{23}\text{ molecules}}\right)\left(\frac{122.45\text{ g}}{1\text{mol}}\right) = 2.56\times10^{15}\text{ g}$$

7. Calculate the number of moles in 49.98 grams of Bohrium.

$$49.98\text{g Bh}\left(\frac{1\text{mol}}{270\text{g}}\right) = 0.1851\text{ mol Bh}.$$

8. What is the percent composition of hydrogen peroxide (H_2O_2)?

$H_2O_2 = 2(1.01g) + 2(16.00g) = 34.02\ g$

$\frac{H_2}{H_2O_2} = \frac{2(1.01g)}{34.02} \times 100 = 5.9\ \%\ H$ $\quad \frac{O_2}{H_2O_2} = \frac{2.(16.00g)}{34.02} \times 100 = 94.1\ \%$

9. Determine the empirical and molecular formula for a compound consisting of 56.4 %P and 43.6 %O with a molar mass of 220 g/mol.

$56.4g\ P\left(\frac{1mol}{31.0g}\right) = \frac{1.82mol\ P}{1.82} = 1 \times 2$

$43.6g\ O\left(\frac{1mol}{16.00g}\right) = \frac{2.725mol\ O}{1.82} = 1.5 \times 2$

P_2O_3

10. Use the equation below to answer the following questions.

$2NaCl(aq) + H_2SO_4(aq) \rightarrow 2HCl(g) + Na_2SO_4(aq)$

a. Determine the limiting reactant and excess reactant when 112 grams of sodium chloride react with 203 grams of sulfuric acid. What mass of the excess reactant is left over after the reaction is complete?

$112g\ NaCl\left(\frac{1mol}{58g}\right) =$ $\quad 203g\ H_2SO_4\left(\frac{1mol}{98g}\right) =$

NaCl is limiting

$112g\ NaCl\left(\frac{1mol}{58g}\right)\left(\frac{1mol\ H_2SO_4}{2mol\ NaCl}\right)\left(\frac{98g}{1mol\ H_2SO_4}\right) = 94.6g$

$203g - 94.6g = 108g$ Excess H_2SO_4

b. What mass of sodium sulfate is produced?

$112g\ NaCl\left(\frac{1mol}{58g}\right)\left(\frac{1mol\ Na_2SO_4}{1mol\ NaCl}\right)\left(\frac{142g}{1mol\ Na_2SO_4}\right) = 274g\ Na_2SO_4$

c. Calculate the percent yield if 122 g of sodium sulfate is obtained during experimentation.

$\frac{122}{274} \times 100 = 45\ \%$

Unit 9 → States of Matter

Vocabulary

amorphous solid	atmosphere	barometer
boiling point	condensation	crystalline solid
Dalton's law of partial pressures	deposition	diffusion
dipole-dipole forces	dispersion forces	elastic collision
evaporation	freezing point	Graham's law of effusion
hydrogen bond	kinetic-molecular theory	melting point
pascal	phase diagram	pressure
sublimation	surface tension	surfactant
temperature	triple point	unit cell
vaporization	vapor pressure	viscosity

Objectives

- **Use** the kinetic-molecular theory to explain the behavior of gases.
- **Describe** how mass affects the rates of diffusion and effusion.
- **Explain** how gas pressure is measured and **calculate** the partial pressure of a gas.
- **Describe** and **compare** intramolecular and intermolecular forces.
- **Distinguish** among intermolecular forces.
- **Apply** kinetic-molecular theory to the behavior of liquids and solids.
- **Relate** properties such as viscosity, surface tension, and capillary action to intermolecular forces.
- **Compare** the structures and properties of different types of solids.
- **Explain** how the addition and removal of energy can cause a phase change.
- **Interpret** a phase diagram.

Short Answer and Problem-Solving

11. What is the ratio of diffusion rates for sufur dioxide and nitrogen dioxide? Which gas diffuses faster?

64 46

$$\frac{\text{rate } NO_2}{\text{rate } SO_2} = \frac{\sqrt{64}}{\sqrt{46}} = \frac{8}{6.8} = 1.17$$

NO_2 diffuses 1.17 x faster than SO_2

12. Find the partial pressure of carbon dioxide in a gas mixture with a total pressure of 30.4 kPa if the partial pressures of the other two gases in the mixture are 16.5 kPa and 3.7 kPa. Convert the partial pressure carbon dioxide to psi.

$P_T = P_1 + P_2 + P_3$

$30.4 - 16.5 - 3.7 =$ **10.2 kpa**

Unit 10 → Gases

Vocabulary

Avogadro's principle	Boyle's law	Charles's law
combined gas law	Gay-Lussac's law	ideal gas constant
ideal gas law	molar volume	

Objectives

- **State** Boyle's law, Charles's law, and Gay-Lussac's law.
- **Apply** the three gas laws to problems involving the pressure, temperature, and volume of a gas.
- **State** the relationship among temperature, volume, and pressure as the combined gas law.
- **Apply** the combined gas law to problems involving the pressure, temperature, and volume of a gas.
- **Relate** numbers of particles and volumes by using Avogadro's principle.
- **Relate** the amount of gas present to its pressure, temperature, and volume by using the ideal gas law.
- **Compare** the properties of real and ideal gases.
- **Determine** volume ratios for gaseous reactants and products by using coefficients from a chemical equation.
- **Calculate** amounts of gaseous reactants and products in a chemical reaction using the gas laws.

Short Answer and Problem-Solving

13. Use Boyle's, Charles's, or Gay-Lussac's law to calculate the missing value in each problem below.

P_1 = ?	V_1 = 3.1 L	P_2 = 2.04 atm	V_2 = 6.7 L

$P_1V_1 = P_2V_2$ $\quad P_1 = \frac{P_2V_2}{V_1}$ $\quad P_1 = \frac{(2.04\text{ atm})(6.7\text{ L})}{(3.1\text{ L})} = 4.4\text{ atm}$

V_1 = 873 ml	T_1 = 365 K	V_2 = ?	T_2 = 345 K

$\frac{V_1}{T_1} = \frac{V_2}{T_2}$ $\quad V_2 = \frac{V_1T_2}{T_1}$ $\quad V_2 = \frac{(873\text{ mL})(345\text{ K})}{(365\text{ K})} = 825\text{ L}$

P_1 = 101 kPa	T_1 = 210 K	P_2 = 215 kPa	T_2 = ?

$\frac{P_1}{T_1} = \frac{P_2}{T_2}$ $\quad T_2 = \frac{P_2T_1}{P_1}$ $\quad T_2 = \frac{(215\text{ kPa})(210\text{ K})}{(101\text{ kPa})} = 447\text{ K}$

14. A balloon will burst at a volume of 2.0 L. If the gas in a partially filled balloon occupies 0.75 L at a temperature of 21 °C, and a pressure of 990 kPa, what is the temperature at which it will burst if the pressure is 1010 kPa at the time in breaks?

$P_1 = 990\text{ kpa}$ $\quad P_2 = 1010\text{ kpa}$

$V_1 = 0.75\text{ L}$ $\quad V_2 = 2.0\text{ L}$

$T_1 = 294\text{ K}$ $\quad T_2 = X$

$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$ $\quad T_2 = \frac{P_2V_2T_1}{P_1V_1}$

$T_2 = \frac{(1010\text{ kPa})(2.0\text{ L})(294\text{ K})}{(990\text{ kPa})(0.75\text{ L})} = 8.0 \times 10^2$

15. Calculate the volume a gas will occupy under the following conditions: 3.00 mol H_2 at 0.98 atm and 24 °C.

$PV=nRT \quad V=\frac{nRT}{P} \quad 3.00\,mol\left(\frac{0.0821\,L\cdot atm}{K\cdot mol}\right)\left(\frac{297\,K}{1}\right)\left(\frac{1}{0.98\,atm}\right)=$ **75 L**

16. If 50 L of nitrogen are used with excess hydrogen to produce ammonia, what volume of ammonia is formed at STP?

$$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$$

$50\,L\,N_2\left(\frac{1\,mol}{22.4\,L}\right)\left(\frac{2\,mol\,NH_3}{1\,mol\,N_2}\right)\left(\frac{22.4\,L}{1\,mol}\right)=$ **100 L**

Final Exam
Example Problem

17. Magnesium metal reacts with oxygen when supplied with sufficient activation energy. A bright white light is produced and some heat is released.

a. Write a balanced chemical equation (including states of matter). Circle your reactant(s) and underline your product(s).

$2Mg(s) + O_2(g) \rightarrow 2MgO(s)$

b. What type of reaction is this? Check all the apply.

combustion	☐	**decomposition**	☐
double replacement	☐	**single replacement**	☐
synthesis	✓		

c. Is the reaction **endothermic** or **exothermic**? Circle your answer.

See reaction above.

d. Identify the limiting reactant and excess reactant if 12.9 grams of magnesium reacts with 28.3 grams of oxygen. What amount of excess reactant is left over once the reaction is complete?

$12.9\,g\,Mg\left(\frac{1\,mol}{24.3}\right)=0.53\,moles\,Mg$ **Mg is limiting**

$28.3\,g\,O_2\left(\frac{1\,mol}{32.0\,g}\right)=0.88\,mol\,O_2$

$12.9\,g\,Mg\left(\frac{1\,mol}{24.3\,g}\right)\left(\frac{1\,mol\,O_2}{2\,mol\,Mg}\right)\left(\frac{32\,g\,O_2}{1\,mol\,O_2}\right)=8.5\,g\,O_2 \qquad 28.3\,g-8.5\,g=$ **19.8 g Excess O_2**

e. How many atoms of magnesium were used?

$12.9\,g\,Mg\left(\frac{1\,mol}{24.3\,g}\right)\left(\frac{6.02\times10^{23}}{1\,mol}\right)=$ **3.20×10^{23} atoms.**

f. If the reaction occurred at STP, what is the volume of oxygen gas that was used?

~~PV=nRT~~ $8.5\text{g } O_2 \left(\frac{1\text{mol}}{32\text{g}}\right)\left(\frac{22.4\text{L}}{1\text{mol}}\right) = \boxed{5.95\text{L } O_2}$ 6.0 2SF

g. What is the mass of the product that is formed?

$12.9\text{g Mg}\left(\frac{1\text{mol}}{24.3\text{g}}\right)\left(\frac{2\text{mol MgO}}{2\text{mol Mg}}\right)\left(\frac{40.3\text{g}}{1\text{mol MgO}}\right) = \boxed{21.4\text{g MgO}}$

h. Calculate the percent yield if 0.0115 grams is obtained during experimentation.

$\frac{0.0115\text{g}}{21.4\text{g}} \times 100 = 0.054\%$

i. Determine the percent composition of the compound that is produced.

MgO $\frac{24.3}{40.3} \times 100 = 60\%$ Mg

~~40~~

$100 - 60 = 40\%$ O