Chem ③ F'17

Chemistry Unit 3

Primary reference: ***Chemistry: Matter and Change*** **[Glencoe, 2017]**

Topic	Essential Knowledge	Study Support
Scientific Investigation 1.3 **SOL 1g, 1h**	Use unit cancelation method for stoichiometry. Use graphing calculators and probeware to investigate gas behavior.	**Ch 11:** Read pp. 368-372 on stoichiometry and units cancellation **Ch 2:** Graphing and data representation: pp. 55-58 (See also: math handbook section, pp. 956-965)
Nomenclature, Formulas, and Reactions **3.3** **SOL 3a,3b,3c,3d,3e**	**Polyatomic ions** are a group of atoms covalently bonded together that have a charge, and they travel "as a package" without splitting up. Use subscripts outside of parantheses to balance the charges of polyatomic ions when more than one is present in compound, $(NH_4)_2SO_4$. Do not reduce subscripts of polyatomics. When two or more substances combine to form a single product, the reaction is called a **synthesis reaction,** also known as a **combination** reaction. In a **decomposition reaction**, a compound breaks down into two or more simpler substances. In a **single replacement reaction** one element takes the place of another in a compound. Ex) $A + BC \rightarrow AC + B$ In a **double replacement reaction** the positive portions of two ionic compounds are interchanged. Ex) $AB + CD \rightarrow AD + CB$ **Combustion reactions** occur when a substance is heated in the presence of oxygen. Many combustion reactions involve the heating of a hydrocarbon in the presence of oxygen to form carbon dioxide and water.	**Ch 7:** Read pp 221-222 on polyatomic ions. Know the following polyatomic ions: OH^-, SO_4^{-2}, NO_3^-, PO_4^{-3}, CO_3^{-2} and NH_4^+ **Ch 9:** Read pp. 289-298 on reaction types.
Molar Relationships 4.3 **SOL 4a,4b**	Because matter cannot be created or destroyed, **the total mass of the products is equal to the total mass of the reactants in a chemical reaction.** Molar masses from the periodic table and mole ratios from the balanced equation can be used to calculate the mass of a reactant or product. (Mole-mole, mass-mass, particle-particle, gas volume-mole at STP) At STP (which is 1 atm of pressure, and 0° C), 1 mole of any gas occupies a volume of 22.4 L. At non-standard temperature and pressure, the volume of a mole of gas will vary. **An increase in temperature will cause an increase in volume** (directly proportional) and **an increase in pressure will cause a decrease in volume** (inversely proportional).	**Ch 11:** **Read sections 1 and 2** on stoichiometry, and practice. **Ch 13:** Read pp 452-453 on gas stoichiometry
Phases of Matter and Kinetic Molecular Theory **5.3** **SOL 5a,5b**	**Pressure and temperature** both affect the volume that a gas occupies. The pressure and volume of a sample of a gas at constant temperature are *inversely* proportional to each other (Boyle's Law). **Boyle's Law Equation:** $P_1V_1 = P_2V_2$ At constant pressure, the volume of a fixed amount of gas is *directly* proportional to its absolute temperature (Charles' Law). **Charles' Law Equation:** $V_1/T_1 = V_2/T_2$ At constant volume, the pressure of a fixed amount of gas is *directly* proportional to its pressure. **Gay-Lussac's Equation:** $P_1/T_1 = P_2/T_2$	**Ch 13:** Read pp. 442-448 on gas pressure, temperature and pressure interactions

Unit 3 Objectives Chemistry: Matter and Change (Glencoe, 2017)

I. Ionic Compounds with Polyatomic Ions
    A. Polyatomic Ions
    B. Names ↔ Formulas Ternary Ionic Compounds
    C. Mixed naming (molecular and ionic)
II. Calculating Percent Composition (Revisiting molar mass)
III. Identifying Reaction Types: single replacement, double replacement, synthesis, decomposition, or combustion
IV. Stoichiometry—Calculating Theoretical Yields
    A. Mole-mole
    B. Mole to particles
    C. Mole to grams
    D. Mole to gas volume at STP
    E. Mixed stochiometry
V. Gases at non-STP Conditions
    A. Kinetic Theory and Gas Particle Properties
    B. Gas Pressure (units, atmospheric pressure, altitude, air pressure)
    C. Kinetic Energy and Kelvin Temperature Scale
    D. Variables describing gases (pressure, temperature, volume, quantity/moles)
    E. Boyle's Law
    F. Charles's Law
    G. Gay-Lussac's Law

Objectives (SOL)

1. Review the following areas on the periodic table: alkali metals, alkaline earth metals, halogens, noble or inert gases, representative elements, transition metals, non-metals, metals, and metalloids.(2d)
2. Review using the roman numeral Stock System to identify and name transition metal ions.(3a)
3. Memorize the names, formulas and charges of the polyatomic ions OH^-, SO_4^{2-}, NO_3^-, PO_4^{3-}, CO_3^{2-}, HCO_3^-, $CH_3CO_2^-$ and NH_4^+
4. Write the formulas for ionic and molecular compounds given their names and *visa versa*.(3a) for both ionic and molecular compounds.
5. Calculate the percent composition of a compound.(4a)
6. Classify a chemical reaction by the following five types: synthesis, decomposition, single replacement, double replacement, and combustion. (3e)
7. Calculate theoretical chemical quantities from balanced equations(4b)
8. Memorize the STP conditions for pressure in mmHg, torr, atm, and kPa. You will also be able to convert between them.
9. Explain the relationship between increasing kinetic energy and increasing temperature.
10. Discuss the three characteristics of ideal gases according to the kinetic theory
11. Use Boyle's law to calculate gas pressure-volume changes
12. Use Charles's law to calculate gas temperature-volume changes
13. Use Gay-Lussac's law to calculate pressure-temperature changes

POLYATOMIC IONS

Poly- means <u>many</u> and *-atomic* means <u>atoms</u>, so polyatomic ions are *ions* with >1 atom.

We've already learned about monatomic ions. (Mono- means <u>one</u>).

Examples of monatomic ions: Cl^-, Na^+, K^+, Br^-... Fe^{3+}

Who ate what where? Mnemonic Device for 5 Common Polyatomic Anions

Nick the CaMeL -ate CLaM for SuPPeR in PHoeNix

The first letter (or two letters, for "clam") is the first element.
The number of consonants ("**Nick**": ***N***, ***c***, and ***k*** = 3 consonants) is the number of oxygen atoms.
The number of vowels ("Nick": ***i*** = 1 vowel) is the charge on the entire polyatomic ion.

Use the mnemonic to write the 5 polyatomic anions' chemical formulas ***and label them***.

NO_3^-	CO_3^{2-}	ClO_3^-	SO_4^{2-}	PO_4^{3-}
nitrate	carbonate	chlorate	sulfate	phosphate

There are two more polyatomic ions you must know:

hydroxide anion	**ammonium** cation
OH^-	NH_4^+

NH_4OH

[IMPORTANT: Atom that form negative charges (anions) usually end in <u>-ide</u>, and atoms that form positive charges can end in <u>-ium</u>.]

Additional Information & Tips:

Anions (negatively-charged ions) that end in "***-ate***" or "***-ite***" have oxygen atoms. Professionally, these are called <u>oxyanions</u> (and that makes a lot of sense. Look at the name!)

Chromate (CrO_4^{2-}) is an anion with the two elements <u>chromium</u> & <u>oxygen</u>.

Silicates (SiO_x) are compound that is made of the elements <u>silicon</u> & <u>oxygen</u>. The "x" means that the number of oxygens can vary.

potassium manganate
K Mn O

The "normal" version of the 5 main polyatomic anions (nitrate, carbonate, chlorate, sulfate, phosphate), all end in ___________. This is what you get from the normal Nick the Camel ☺

Weird Endings to Polyatomic Ions: The # of Oxygen Changes, BUT NEVER THE ______________!

If there is **1 extra oxygen atom**, the root—or main element—of the name (*nitr-, carbon-, sulf-, chlor-, phosph-*) is surrounded by PER_____ATE
If there is the "normal" number of carbons, it's what you already know: _____ATE

How to Remember:

Hey… are you super great?

If you've got an *extra oxygen*, then you're "**super great**" so use "***per-***" and "***-ate***"!

…Are you just great? (Normal) ClO_3^- → ClO_4^-

If you've got all of your *normal # of oxygens*, then you're just "**great**" so just use "***-ate***"!

Uh-oh… Now you have *fewer oxygens* than you normally have from Nick the Camel. ClO_3^- → ClO_2^-

If there is **1 fewer oxygen**, the root is now surrounded by _____ITE.
If there are **2 fewer oxygens**, the root is now surrounded by HYPO_____ITE. ClO^-

SO_3^{2-}

How to Remember:

Missing 1 oxygen? You're not great. You're just "***-ite***"

Missing 2 oxygens? You're less than "-ite." You're "***hypo____ite***"

(Hypo- means less than, lower than, under, below, decreased, *etc. Think:* hypothermia, hypoglycemic)

Purely Polyatomic Practice: *If you have the name, give the formula. If you have the formula, give the name.*

1) NO_3^- nitrate
2) Hyposulfite SO_2^{2-}
3) NH_4^+ ammonium
4) PO_3^{3-} phosphite
5) Hypochlorite ClO^-
6) Nitrite NO_2^-
7) Carbonate CO_3^{2-}
8) PO_4^{3-} phosphate
9) Chlorate ClO_3^-
10) SO_4^{2-} sulfate

ClO_3^- BrO_3^- IO_3^- BrO^- IO_2^- SO_4^{2-} NO_3^-

REMEMBER: Polyatomic ions are like "packages" and "best friends forever," which means they travel together. The charge applies to the entire package. They do get into compounds with cations. **$NaNO_3$** is **sodium nitrate**. **$MgSO_4$** is **magnesium sulfate**. **Li_2CO_3** is **lithium carbonate**. **$Ca(ClO_3)_2$** is **calcium chlorate**… there are 2 "packages" of chlorate. Get it? Always make sure your (-) and (+) charges are balanced in the neutral compound!

Sr^{2+} SO_3^{2-} $(NH_4)_3PO_4$

Practice Quiz: Together as a class.

- Write the chemical formula for strontium sulfite. $SrSO_3$
- What is ammonium? NH_4^+. It's positively charged, so it's a(n) cation, meaning it comes FIRST when you name something, even though it's not a metal.
  Write the chemical formula for ammonium chloride. ______________
- Write the chemical formula for sodium hydroxide. ______________
- $Zn(NO_3)_2$ is Zinc nitrate
- Vanadium(V) hydroxide is ~~V^{5+} OH^-~~ → $V(OH)_5$
- Write the chemical formula for ammonium hydroxide. ______________
- Write the chemical formula for rubidium oxide. ______________. Why doesn't rubidium have roman numerals in parentheses?
- Write the chemical formula for titanium(IV) oxide ______________
- Dinitrogen pentasulfide is ______________
- Xenon hexafluoride is XeF_6
- Why is monocarbon disulfide an incorrect name?
- FeO and Fe_2O_3 are both iron oxide compounds. What is different about the irons in each compound?
- Why is tripotassium phosphate an incorrect ionic name?
- Lead(IV) oxide is ______________.

Assessment: MUST include oxidation state (roman numerals in parentheses) for transition metals when you write the name. All compounds are neutral, so do NOT include charges in your final answer on the line. Tip: Do the switchy thing, or do the reverse… depending on what you're doing.

1) Cobalt(II) nitrite $Co(NO_2)_2$ (Co^{2+} NO_2^-; NO_3^-)
2) Phosphorus trichloride PCl_3
3) Ammonium bromide NH_4Br (NH_4^+ Br^-)
4) Cesium selenide ______________
5) Iron(II) perchlorate $Fe(ClO_4)_2$ (Fe^{2+} ClO_4^-; -ic -ate, ClO_3^-)
6) Nitrogen disulfide ______________
7) Diphosphorus tetroxide ______________
8) Oxygen difluoride ______________
9) Dinitrogen monoxide ______________
10) Nickel(III) nitride ______________
11) Fe_3N_2 ______________
12) CdS ______________
13) $Mg(ClO_4)_2$ ______________
14) NCl_3 ______________
15) $Al(NO_3)_3$ ______________
16) K_3PO_4 ______________
17) CF_4 ______________
18) SO_2 ______________
19) TiN titanium(III) nitride
20) W_2O_5 ______________

Chapter 6 Part 2: Chemical Names and Formulas

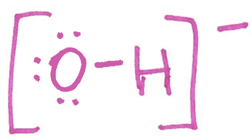
A. Polyatomic Ions

1) A polyatomic ion is a group of covalently bonded atoms that carries a charge—in other words a charged molecule.

2) You need to memorize these eight: OH^-, NO_3^-, CO_3^{2-}, SO_4^{2-}, PO_4^{3-}, NH_4^+, $CH_3CO_2^-$, HCO_3^-

OH^- hydroxide

+H⁺ → H_2O



NO_3^- nitrate

HNO_3 nitric acid

NO_2^- = ~~nitrate~~ nitrite

CO_3^{2-} carbonate

+2H⁺ → H_2CO_3 (carbonic acid)

SO_4^{2-} = sulfate

SO_3^{2-} = sulfite

+2H⁺ → H_2SO_4 sulfuric acid

PO_4^{3-} = phosphate

→ H_3PO_4 phosphoric acid

NH_4^+ ~~ammonia~~ ammonium

→ ~~NH_3 (ammonia)~~

$CH_3CO_2^-$ acetate

+H⁺ → CH_3CO_2H acetic acid

HCO_3^- hydrogen carbonate

→ bicarbonate

Na^+ HCO_3^-

$NaHCO_3$

baking soda

B. Names ↔Formulas for Polyatomic Ionic Compounds

1) Treat them just like binaries, except use parentheses when there is more than one polyatomic.

   Examples: $Mg(OH)_2$ $(NH_4)_2S$

2) Name to Formula Practice

   Potassium sulfate

   Aluminum nitrate

   Manganese(IV)carbonate

   Calcium hydroxide

   Ammonium phosphate

   Iron(III) acetate

3) Formula to name practice

$NaHCO_3$

$Sn(CO_3)_2$

$Cu(CH_3CO_2)_2$

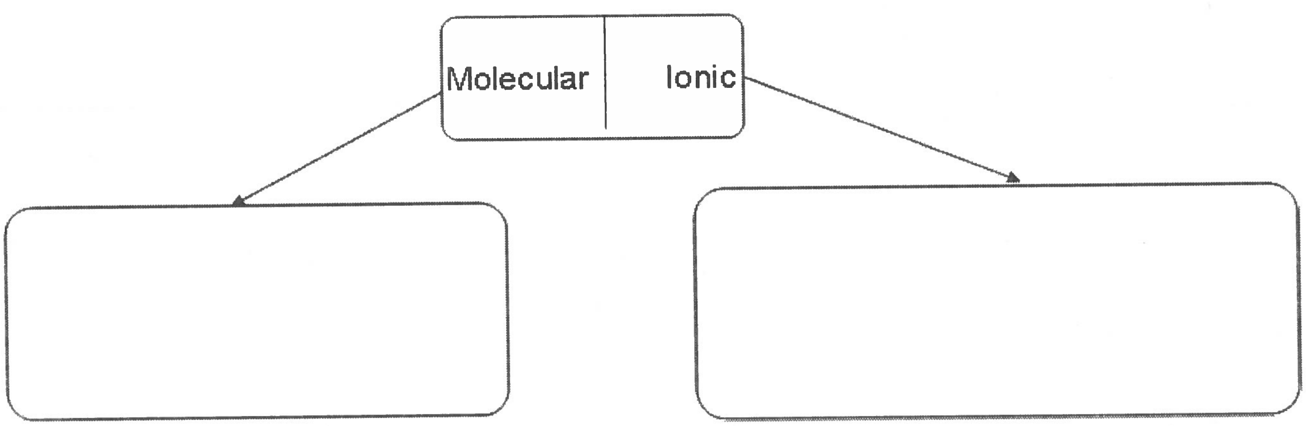
$Cr(SO_4)_3$

$(NH_4)_2CO_3$

$Mg(OH)_2$

Mixed Ionic and Molecular Naming

Formula to Name Flowchart



NH_4Cl

N_2O_5

$Pb(SO_4)_2$

SO_3

V_2O_5

$Zn(HCO_3)_2$

Chapter Seven Part 2: Calculating Percent Composition of Elements in a Compound

Percent Composition: ***the percent by mass of an element in a compound*** Mg^{2+} O^{2-}

Experimental based problems

A 8.20 g piece of magnesium combines completely with 5.40 grams of oxygen to form a compound. What is the percent composition of magnesium in this compound?

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

(8.20g) (5.40 g) (13.60g)

$\% Mg = \frac{\text{mass Mg}}{\text{mass compound}} (\times 100) = \frac{8.20g}{13.60g} \times 100 = 60.2\% Mg$

When a 14.2 g sample of mercury(II) oxide is decomposed into its elements by heating, 13.2 g of Hg is obtained. What is the percent composition of oxygen in this compound?

$HgO(s) \xrightarrow{\Delta} Hg(l) + O_2(g)$

(14.2g) = (13.2g) + (1.0g)

$\% \text{ Oxygen} = \frac{1.0 g}{14.2 g} \times 100 = 7\%$ oxygen.

Calculating Percent Composition from the Formula

Equation: % mass of element = $\frac{\text{total mass of the element in the compound}}{\text{molar mass of entire compound}} \times 100$

→ Find the percent composition of chlorine in iron(III) chloride

Fe^{3+} Cl^- → $FeCl_3$

$\% Cl = \frac{\text{mass Cl}}{\text{mass of compound}} \times 100 = \frac{(3 \times 35.45)}{(1 \times 55.85) + (3 \times 35.45)} \times 100$

$= 65.6\%$ Cl by mass

Find the percent composition of oxygen in calcium nitrate

Ca^{2+} NO_3^- → $Ca(NO_3)_2$

1 Ca
2 N
6 Oxy

$\% \text{ Oxygen} = \frac{(6 \times 16.0)}{(164.09)} \times 100$

= 58.5% Oxygen

What is the percent composition of sodium in sodium phosphate?

Na^+ PO_4^{3-}

$Na_3PO_4 = 163.94$ g/mol

$$\% Na = \frac{(3 \times 23.0)}{(163.9)} \times 100 = 42\% \text{ Na by mass}$$

3 Na
1 P
4 Oxy

Calculate the percent composition of nitrogen in ammonium oxide.

NH_4^+ O^{2-} → $(NH_4)_2O$

$$\% N = \frac{(2 \times 14.0)}{(52.0)} \times 100 = 53.8\% \text{ N by mass}$$

2 N
8 H
1 O

In which compound does carbon have a greater percentage of the composition by mass? Justify your answer mathematically.

CCl_4 **C_2F_2** **Chromium(III) carbonate**

Cr^{3+} CO_3^{2-}

$Cr_2(CO_3)_3$

$$\% C = \frac{(3 \times 12.0)}{(284.0)} \times 100$$

$= 12\%$ C

Ch 8 Part 2

Balancing equations with polyatomic ions involved—a short cut.

Treat the polyatomics as a single unit if they are unchanged from the product to reactant side. Water can be treated as HOH.

2 $AgNO_3$ + 1 Cu → 1 $Cu(NO_3)_2$ + 2 Ag

1 K_3PO_4 + 1 $Al(NO_3)_3$ → 3 KNO_3 + 1 $AlPO_4$

1 H_2SO_4 + 2 NaOH → 1 Na_2SO_4 + 2 H_2O

HOH

HNO_3 vs HNO_2 HCl $HClO_3$ $HClO_2$

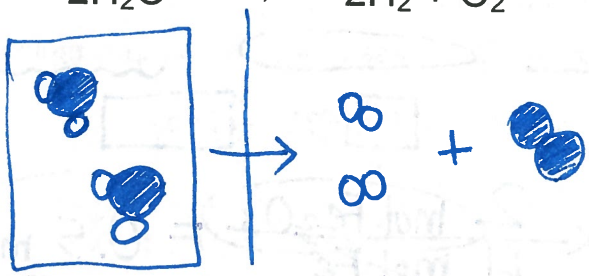
Chapter 8 Part 2: Reaction Types

Reaction type	General equation	Description	Unbalanced Examples
Single-replacement	$AX + Y \rightarrow YX + A$	A comp. & an element react: ... a new compound & an element is removed	$Fe + Cu(NO_3)_2 \rightarrow Fe(NO_3)_2 + Cu$ $Zn + HCl \rightarrow ZnCl_2 + H_2$ $AgNO_3 + Cu$□ $\rightarrow Cu(NO_3)_2 + Ag$ $Cl_2 + NaBr \rightarrow NaCl + Br_2$
Double-replacement	$AB + XY \rightarrow AY + XB$	2 compounds (usually ionic) "switch partners"	$AgNO_3 + NaCl \rightarrow AgCl + NaNO_3$ $FeS + HCl \rightarrow FeCl_2 + H_2S$ $KOH + H_2SO_4 \rightarrow K_2SO_4 + H_2O$
Synthesis	$A + B \rightarrow AB$	≥ 2 elements combine to create a ~~combo~~ compound	$H_2 + O_2 \rightarrow H_2O$ ~~NO + NO → N_2O_2~~ $Fe + O_2 \rightarrow Fe_2O_3$ $2NO_2 \rightarrow N_2O_4$
Decomposition	$AB \rightarrow A + B$	a compound "breaks" into simpler pieces (elements	$H_2O \rightarrow H_2 + O_2$ $MgCl_2 \rightarrow Mg(s) + Cl_2(g)$ $CaCO_3 \rightarrow CaO + CO_2$ $Ba(ClO_3)_2 \rightarrow BaCl_2 + O_2$
Combustion	$C_xH_yO_z + O_2 \rightarrow CO_2 + H_2O$	a carbon compound reacts w/ O_2 to create $CO_2 + H_2O$	$CH_4 + O_2 \rightarrow CO_2 + H_2O$ $C_2H_6O + O_2 \rightarrow CO_2 + H_2O$

Chapter 9 Part 1: Introduction to Stoichiometry

Interpreting a Chemical Equation:

$$2H_2O \rightarrow 2H_2 + O_2$$



The recipe for Dr. Seuss Special

1 ham + 2 green eggs = 1 Dr. Seuss Special

Based on this recipe:

1) If I made 3 Dr. Seuss Specials, how many hams did I need?

$\frac{3\ DSS}{1} \times \frac{1\ hams}{1\ DSS} = 3\ hams$

2) If I made 8 Dr. Seuss Specials, how many green eggs did I need?

$\frac{8\ DSS}{1} \times \frac{2\ eggs}{1\ DSS} = 16\ eggs$

3) If I have 5 hams, how many green eggs to I need to use all the hams?

$\frac{5\ hams}{1} \times \frac{1\ DSS}{1\ hams} \times \frac{2\ eggs}{1\ DSS} = 10\ eggs$

4) If I have 30 green eggs, how many hams do I need to use all the eggs?

$\frac{30\ eggs}{1} \times \frac{1\ DSS}{2\ eggs} \times \frac{1\ hams}{1\ DSS} = 15\ hams$

5) If I have 4 hams and 300 green eggs, how many Dr. Seuss specials can I make?

6) If I have 510 hams and 32 green eggs, how many Dr. Seuss specials can I make?

Mole Ratios

Here's an example of a chemical recipe: $4Fe + 3O_2 \rightarrow 2Fe_2O_3$

Based on the recipe (balanced equation) above:

a) If I have 1.0 mole of Fe with excess oxygen, how many moles of Fe_2O_3 will I make?

rust

iron (III) oxide

$4Fe + 3O_2 \rightarrow 2Fe_2O_3$

$$\frac{1.0 \text{ mol Fe}}{1} \times \frac{2 \text{ mol } Fe_2O_3}{4 \text{ mol Fe}} = 0.5 \text{ mol } Fe_2O_3$$

b) How many moles of oxygen will I need to react with 1.0 mole of Fe?

$4Fe + 3O_2 \rightarrow 2Fe_2O_3$

$$\frac{1.0 \text{ mol Fe}}{1} \times \frac{3 \text{ mol } O_2}{4 \text{ mol Fe}} = 0.75 \text{ mol } O_2$$

c) How many moles of Fe do I need to produce 6.0 moles of Fe_2O_3?

$4Fe + 3O_2 \rightarrow 2Fe_2O_3$

$$\frac{6.0 \text{ mol } Fe_2O_3}{1} \times \frac{4 \text{ mol Fe}}{2 \text{ mol } Fe_2O_3} = 12 \text{ mol Fe}$$

So, Stoichiometry is simply the calculation of quantities in reactions, and the key to Stoichiometry problems is the **MOLE RATIO** from the balanced equation. *Every Stoichiometry problem uses the* ***MOLE RATIO*** *from the balanced equation*

IIA Mole-Mole Calculations

OYO How many moles of chlorine gas are needed to produce 0.0012 moles of HCl according to the reaction below?

$$2Cl_2(g) + 2H_2O(l) \rightarrow 4HCl(g) + O_2(g)$$

OYO How many moles of oxygen are produced when 3.2 moles of HCl are made?

$$2Cl_2CO(g)\ \ 2H_2O(l) \rightarrow 4HCl(g) + 2CO(g) + O_2(g)$$

OYO Given 6 moles of Aluminum, find the moles of copper produced.

$$3CuCl_2(aq) + 2Al(s) \rightarrow 2AlCl_3(aq) + 3\ Cu(s)$$

IIB Mole to Mass

Given 3.0 moles of Al and excess copper(II)chloride, how many grams of copper will be produced?

$$3CuCl_2(aq) + 2Al(s) \rightarrow 2AlCl_3(aq) + 3\ Cu(s)$$

$$\frac{3.0 \text{ mol Al}}{1} \times \frac{3 \text{ mol Cu}}{2 \text{ mol Al}} \times \frac{63.55 \text{ g Cu}}{1 \text{ mol Cu}} = 285.98 \text{ g Cu}$$

How many grams of water are needed to react with 0.15 moles of chlorine gas?

$$2Cl_2(g) + 2H_2O(l) \rightarrow 4HCl(g) + O_2(g)$$

[ ] → mol Cl_2 → mol H_2O → g H_2O

$$\frac{0.15 \text{ mol } Cl_2}{1} \times \frac{2 \text{ mol } H_2O}{2 \text{ mol } Cl_2} \times \frac{18.0 \text{ g } H_2O}{1 \text{ mol } H_2O}$$

$= 2.7\ g\ H_2O$

IIC Mole to Count (number of representative particle) 2SF

How many molecules of oxygen gas are needed to react completely with 40. moles of propanol (C_3H_6O)?

$$C_3H_6O + 4O_2 \rightarrow 3CO_2 + 3H_2O$$

$$\frac{40.\ \text{mol } C_3H_6O}{1} \times \frac{4\ \text{mol } O_2}{1\ \text{mol } C_3H_6O} \times \frac{6.02E23\ \text{molecules } O_2}{1\ \text{mol } O_2}$$

How many water molecules will be produced when 0.056 moles of oxygen are consumed?

$$C_3H_6O + 4O_2 \rightarrow 3CO_2 + 3H_2O$$

mol O_2 → mol H_2O → H_2O molecules

IID Mole to Volume

How many liters of oxygen gas are need to react completely with 13 moles of methane, CH_4 at STP?

$$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$$

$$\frac{13\ \text{mol } CH_4}{1} \times \frac{2\ \text{mol } O_2}{1\ \text{mol } CH_4} \times \frac{22.4\ \text{L } O_2}{1\ \text{mol } O_2} = 580\ \text{L } O_2$$

OYO

How many liters of oxygen gas will be produced from the decomposition of 2.0 moles of potassium chlorate? (oxygen candle reaction)

$$2KClO_3(s) \rightarrow 2KCl(s) + 3O_2(g)$$

$$\frac{2.0\ \text{mol } KClO_3}{1} \times \frac{3\ \text{mol } O_2}{2\ \text{mol } KClO_3} \times \frac{22.4\ \text{L } O_2}{1\ \text{mol } O_2}$$

$= 67.2\ \text{L } O_2$

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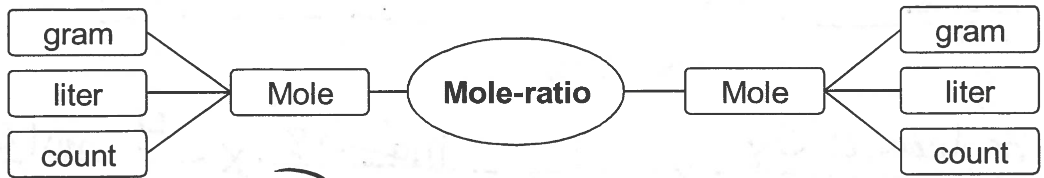
Mixed Stoichiometry



1. How many liters of oxygen will be needed to react completely with 58 grams of C_3H_8 at STP?

   propane

   $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$

   $\frac{58 g\ C_3H_8}{1} \times \frac{1\ mol\ C_3H_8}{44.0\ g\ C_3H_8} \times \frac{5\ mol\ O_2}{1\ mol\ C_3H_8} \times \frac{22.4\ L\ O_2}{1\ mol\ O_2}$

   = 150

2. How many liters of oxygen will react with 4.2 moles of phosphorus to form diphosphorus pentoxide at STP?

   $4P + 5O_2 \rightarrow 2P_2O_5$

3. How many grams of iron will react with 562.2 grams of oxygen to form rust?

   $4Fe(s) + 3O_2(g) \rightarrow 2Fe_2O_3$

   $\frac{562.2 g\ O_2}{1} \times \frac{1\ mol\ O_2}{32.0\ g\ O_2} \times \frac{4\ mol\ Fe}{3\ mol\ O_2} \times \frac{55.85\ g\ Fe}{1\ mol\ Fe}$

   = 1308 g Fe

4. How many grams of phosgene, Cl_2CO, will produce 1.22 grams of hydrochloric acid, HCl, in the presence of excess water?

   OYO NOW

   $Cl_2CO + H_2O \rightarrow 2HCl + CO_2$

   g HCl → mol HCl → mol Cl_2CO → g Cl_2CO

5. How many grams of iron(III) oxide (rust) are produced when 2.3 moles of oxygen reacts with iron?

   (Ans = 240 g) $4Fe(s) + 3O_2(g) \rightarrow 2Fe_2O_3$

molecules S_8 → mol S_8 → mol C → g C

6. How many grams of carbon will react completely with 3×10^{21} molecules of S_8 to form carbon disulfide?

$$4C(s) + S_8(s) \rightarrow 4CS_2(g)$$

$$\frac{3E21 \text{ molecules } S_8}{1} \times \frac{1 \text{ mol } S_8}{6.02E23 \text{ molec. } S_8} \times \frac{4 \text{ mol C}}{1 \text{ mol } S_8} \times \frac{12 \text{ g C}}{1 \text{ mol C}}$$

7. How many liters of oxygen will be needed to react with 0.42 moles of nitrogen to make dinitrogen pentoxide at STP?

$$2N_2 + 5O_2 \rightarrow 2N_2O_5$$

8. How many grams of butane, C_4H_{10}, are needed to react completely with 82 liters of oxygen at STP?

$$2C_4H_{10} + 13O_2 \rightarrow 8CO_2 + 10H_2O$$

$$\frac{82 \text{ L } O_2}{1} \times \frac{1 \text{ mol } O_2}{22.4 \text{ L } O_2} \times \frac{2 \text{ mol } C_4H_{10}}{13 \text{ mol } O_2} \times \frac{58 \text{ g } C_4H_{10}}{1 \text{ mol } C_4H_{10}} = 33 \text{ g } C_4H_{10}$$

9. How many liters of oxygen are required to react with 25.5 g of magnesium at STP?

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

g Mg → mol Mg → mol O_2 → L O_2

MM of Mg; use B.Eq.; 22.4 L/mol

10. How many molecules of ammonia are produced from 3.0 liters of hydrogen reacting with excess nitrogen at STP?

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

motion

Chapter 10 Part 1: Gas Properties Skeleton Notes

Kinetic Theory: Particles are constantly in motion (★ HOTTER matter has FASTER particle motion)

I. Kinetic Theory as applied to gases.

$KE = \frac{1}{2}mv^2$

A) Gas particles have negligible volume compared to container size*
B) Gas particles do not attract or repel each other*
C) Gas particle move constantly, rapidly and randomly
D) All collisions perfectly elastic (particles collide like billiard balls, not marshmallows)

*key characteristics of "ideal gases"

II Gas pressure (units, atmospheric pressure, altitude and air pressure)

A) Gas pressure caused by collisions of particles (w/ momentum) w/ the container ("pushing")

B) Units: SI unit: pascal (Pa) (N/m^2) $P = \frac{Force}{Area}$ $\frac{(lbs)}{(in^2)}$

C) Standard Temperature and Pressure (STP) = 0°C & 1 atm (sea level)

1. Other units: 1 atm = 101.3 kPa = 760 mmHg = 760 torr = 14.7 psi ($\frac{lbs}{in^2}$)

2. Converting between pressure units.

5.2 kPa = ? mmHg

$\frac{5.2\ kPa}{1} \times \frac{760\ mmHg}{101.3\ kPa} =$

15 mmHg = ? atm

$\frac{15\ mmHg}{1} \times \frac{1\ atm}{760\ mmHg} \approx 0.01\ atm$

37.0 psi = ? torr

$\frac{37.0\ psi}{1} \times \frac{760\ torr}{14.7\ psi}$

429.7 kPa = ? atm = ? psi = ? torr

OVO

III Kinetic Energy and Kelvin temperature scale

A) When we measure temperature, we measure average kinetic energy (speed)

B) Gas particle's kinetic energy increases as temperature increases

C) Kelvin Temperature scale is absolute!!! Directly prop. to KE (meas. E)

273 K = 0 °C

D) Temperature note for working with gases. only use Kelvin!!!

$E=mc^2$

$K = T$

$3x^2 ~~+4~~ = 4x^3 ~~+4~~$

Chapter 12 Part 1: Boyles and Charles Law Skeleton Notes

I Variables Describing Gases

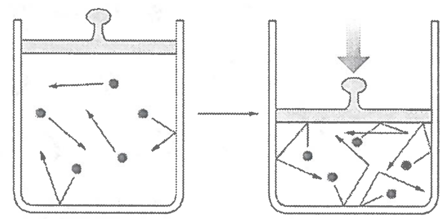
P = pressure   V = volume

T = temperature   n = # of moles (← amount)

II Factors Affecting Gas Pressure

A) Changing the amount of gas particles in a closed container (n).
Doubling the number of gas molecules doubles pressure. Halving the number of molecules halves the pressure
Example: pumping up a playground ball

B) Changing the container gas container volume (T and n stay constant)
Reducing the size of a container increases the gas pressure. Increasing the size decreases gas pressure.
Example: bicycle pump



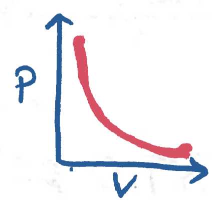
C) Changing the temperature (V and n stay constant)
Increasing the temperature increases pressure. Why?

Example: aerosol can in fire

III The Gas Laws

A) Boyle's Law (Volume-Pressure Change)

1) Verbally: Volume varies inversely with pressure at a constant temperature.



2) Math Equation: $\underbrace{P_1V_1}_{initial} = \underbrace{P_2V_2}_{final}$

Example 1: A balloon contains 11 L of He gas at 101.3 kPA at sea level. What is the balloon's volume in Denver at 85.3 kPa. (assume temperature is constant)

initial	final
$P_1 = 101.3$ kPa	$P_2 = 85.3$ KPa
$V_1 = 11$ L	$V_2 = $ 13 L

$(101.3)(11) = (85.3)V_2$

$\therefore V_2 = 13$ L

Example 2: If a piston compresses the air in a 0.52 Liter cylinder to 0.12 liters at 760 mm Hg. What will be the pressure in the cylinder after compression?

initial	Final
$P_1 = 760$ mmHg	$P_2 = $ ___ mmHg
$V_1 = 0.52$ L	$V_2 = 0.12$ L

$P_1V_1 = P_2V_2$

$\frac{P_1V_1}{V_2} = P_2 \quad \therefore 3300 \text{ mmHg} = P_2$

A) Charles's Law for Temperature-Volume Change

1) Verbally: The volume of a fixed mass of gas is directly proportional to its temperature (Kelvin) at constant pressure. ($\propto$)

2) Math Equation: $\frac{V_1}{T_1} = \frac{V_2}{T_2}$ ← Kelvin

3) A balloon shrinks as it gets colder, and expands as it gets warmer.

Example 1: You buy a helium balloon for your friend's birthday. It has a volume of 8.0 liters in the store at 101.3 kPa and 20.°C. How large will the balloon be after you leave it sitting in your hot car at 60.°C?(pressure still = 101.3 kPa)

Initial	Final
P_1 = ~~101.3 kPa~~	P_2 = ~~101.3 kPa~~
V_1 = 8.0 L	V_2 = ☐ L
T_1 = 293 K	T_2 = 333 K

$$\frac{V_1}{T_1} = \frac{V_2}{T_2} \rightarrow \frac{V_1 T_2}{T_1} = V_2$$

$$\therefore \frac{(8)(333)}{(293)} = 9.0\ L$$

Example 2: Your friend takes the same balloon (8.0 liters at 20°C and 101.3 kPa) with her to Antarctica where the balloon's volume shrinks to 6.9 liters at 101.3 kPa. How cold is it in Antarctica in Kelvins?(Ans = 253 K = _____ with sig figs)

$$\frac{V_1}{T_1} = \frac{V_2}{T_2} \rightarrow \therefore T_2 = \frac{V_2 \cdot T_1}{V_1}$$

$$\frac{8\ L}{293\ K} = \frac{6.9\ L}{☐\ K}$$

$$\therefore T_2 = 253\ K = -20°C$$

B) Gay-Lussac's Law (Pressure-Temperature Interaction)

1) Verbally: The pressure of a gas is directly proportional to its temperature (K) ($\propto$)

2) Math Equation: $\frac{P_1}{T_1} = \frac{P_2}{T_2}$

3) Example 1: The tire pressure in a car's tires is 2.3 atmospheres at 38°C. What will the tire pressure be at -10.°C?

P_1; T_1 = 311 K

$$\frac{2.3\ atm}{311\ K} = \frac{P_2\ atm}{263\ K} \quad \therefore P_2 = ☐\ atm$$

4) Example 2: The pressure in a cylinder of gas is 760 mm Hg at exactly 0°C. What is the pressure of the gas at 500.°C?

$$\frac{760\ mmHg}{273\ K} = \frac{P_2}{773\ K} \quad \therefore P_2 = ☐\ mmHg$$

Advanced Gas Law Practice:

(0.338 • 507)

1) The temperature of an unknown gas begins at 507 K, and is decreased so that the final temperature is 33.8% of the initial temperature. The pressure remains constant, but the volume changed. If the initial volume was 2.48×10^3 L, what is the final volume?

$T_1 = 507$ K $\quad T_2 = 171$ K

$V_1 = 2.48E3$ L $\quad V_2 =$

$$\frac{(2{,}480)\text{ L}}{507\text{ K}} = \frac{838\text{ L}}{171\text{ K}}$$

2) The final pressure of a gas is 240% of the initial pressure, which was 228.8 kPa. The volume of the gas remained *constant* at 857.6 cm^3. Determine the initial temperature if the final temperature was 1800 K.

3) A large spherical balloon, filled with helium, has a radius of 84.0 cm. A student then heats the balloon, increasing the temperature from 40.0°C to 98.0°. Assume that the pressure in the balloon remains constant as both the temperature and volume vary. He measured the radius before and after heating the balloon.

a) Which variable is the independent variable? On which axis does it belong?

b) Which variable is the dependent variable? On which axis does it belong?

c) Calculate the initial (V_1) and final (V_2) volumes of the spherical balloon *with appropriate units*.

d) Calculate the final radius of the spherical balloon in cm.

Lee Block (2) 10/13

Chemistry Unit 3

Primary reference: *CHEMISTRY*, Addison-Wesley

Topic	Essential Knowledge	Study Support
Scientific Investigation 1.3 **SOL 1g, 1h**	Use unit cancelation method for stoichiometry. Use graphing calculators and probeware to investigate gas behavior.	**Ch 10: Read p 270** about making and interpreting graphs.
Nomenclature, Formulas, and Reactions **3.3** **SOL 3a,3b,3c,3d,3e**	**Polyatomic ions** are a group of atoms covalently bonded together that have a charge. Use subscripts outside of parantheses to balance the charges of polyatomic ions when more than one is present in compound, $(NH_4)_2SO_4$. Do not reduce subscripts of polyatomics. When two or more substances combine to form a single product, the reaction is called a **synthesis reaction**, also known as a **combination** reaction. In a **decomposition reaction**, a compound breaks down into two or more simpler substances. In a **single replacement reaction** one element takes the place of another in a compound. Ex) A +BC → AC + B In a **double replacement reaction** the positive portions of two ionic compounds are interchanged. Ex) AB +CD → AD + CB **Combustion reactions** occur when a substance is heated in the presence of oxygen. Many combustion reactions involve the heating of a hydrocarbon in the presence of oxygen to form carbon dioxide and water.	**Ch 6:Read pp 146-147** on polyatomic ions. Know the following polyatomic ions: OH^-, SO_4^{-2}, NO_3^-, PO_4^{-3}, CO_3^{-2} and NH_4^+ **Ch 8: Read pp. 212-223** on reaction types.
Molar Relationships 4.3 **SOL 4a,4b**	Because matter cannot be created or destroyed, **the total mass of the products is equal to the total mass of the reactants in a chemical reaction.** Molar masses from the periodic table and mole ratios from the balanced equation can be used to calculate the mass of a reactant or product. (Mole-mole, mass-mass, particle-particle, gas volume-mole at STP)	**Ch 9: Read pp. 237-239** on stoichiometry. **Ch 12: Read pp 347-349** on Gas Stoichiometry
Phases of Matter and Kinetic Molecular Theory 5.3 **SOL 5a,5b**	**Pressure and temperature** both affect the volume that a gas occupies. The pressure and volume of a sample of a gas at constant temperature are inversely proportional to each other (Boyle's Law). **Boyle's Law Equation: $P_1V_1 = P_2V_2$** At constant pressure, the volume of a fixed amount of gas is directly proportional to its absolute temperature (Charles' Law). **Charles's Law Equation: $V_1/T_1 = V_2/T_2$** At constant volume, the pressure of a fixed amount of gas is directly proportional to its pressure. **Equation: $P_1/T_1 = P_2/T_2$**	**Ch 12: Read pp. 327-338** on gas pressure, temperature and pressure interactions.

Unit 3 Objectives Chemistry, Addison-Wesley, 2002

I. Ionic Compounds with Polyatomic Ions
   A. Polyatomic Ions
   B. Names ↔ Formulas Ternary Ionic Compounds
   C. Mixed naming (molecular and ionic)
II. Calculating Percent Composition (Revisiting molar mass)
III. Identifying Reaction Types: single replacement, double replacement, synthesis, decomposition, or combustion
IV. Stoichiometry—Calculating Theoretical Yields
   A. Mole-mole
   B. Mole to particles
   C. Mole to grams
   D. Mole to gas volume at STP
   E. Mixed stochiometry
V. Gases at non-STP Conditions
   A. Kinetic Theory and Gas Particle Properties
   B. Gas Pressure (units, atmospheric pressure, altitude, air pressure)
   C. Kinetic Energy and Kelvin Temperature Scale
   D. Variables describing gases (pressure, temperature, volume, quantity/moles)
   E. Boyle's Law (p 335#10,11)
   F. Charles's Law (p337#12,13,p356#47,50(concept)
   G. Gay-Lussac's Law (p338#14, p339#15, p356#51)

Objectives (SOL) *book problems*

1. Review the following areas on the periodic table: alkali metals, alkaline earth metals, halogens, noble or inert gases, representative elements, transition metals, non-metals, metals, and metalloids.(2d)
2. Review using the roman numeral Stock System to identify and name transition metal ions.(3a)
3. Memorize the names, formulas and charges of the polyatomic ions OH^-, SO_4^{2-}, NO_3^-, PO_4^{3-}, CO_3^{2-}, HCO_3^-, $CH_3CO_2^-$ and NH_4^+
4. Write the formulas for ionic and molecular compounds given their names and *visa versa*.(3a) *Ionic(p155:#29, p166#,61,) molecular (p159#38) Ionic(p153#26,27; p156#30,31;p167#67,69) Molecular(p159#37)*
5. Calculate the percent composition of a compound.(4a) (p191#31-33;p192#34;p195#41,42;p198#60,61,62)
6. Classify a chemical reaction by the following five types: synthesis, decomposition, single replacement, double replacement, and combustion. (3e)
7. Calculate theoretical chemical quantities from balanced equations(4b)
8. Memorize the STP conditions for pressure in mm Hg, Atm, and kPa. You will also be able to convert between them.
9. Explain the relationship between increasing kinetic energy and increasing temperature.
10. Discuss the three characteristics of ideal gases according to the kinetic theory
11. Use Boyle's law to calculate gas pressure-volume changes
12. Use Charles's law to calculate gas temperature-volume changes
13. Use Gay-Lussac's law to calculate pressure-temperature changes

POLYATOMIC IONS

Poly- means __________ and *-atomic* means __________, so polyatomic ions are *ions* with >1 atom.

We've already learned about monatomic ions. (Mono- means __________).

Examples of monatomic ions: Cl^-, Na^+, K^+, Br^-...

Who ate what where? Mnemonic Device for 5 Common Polyatomic Anions

The first letter (or two letters, for "clam") is the first element.
The number of consonants ("Nick": ***N***, ***c***, and ***k*** = 3 consonants) is the number of oxygen atoms.
The number of vowels ("Nick": ***i*** = 1 vowel) is the charge on the entire polyatomic ion.

Use the mnemonic to write the 5 polyatomic anions' chemical formulas ***and label them***.

There are two more polyatomic ions you must know: **hydroxide** anion and **ammonium** cation

[IMPORTANT: Atom that form negative charges (anions) usually end in __________, and atoms that form positive charges can end in __________.]

Additional Information & Tips:

Anions (negatively-charged ions) that end in "***-ate***" or "***-ite***" have oxygen atoms. Professionally, these are called ______________ (and that makes a lot of sense. Look at the name!)

Chromate (CrO_4^{2-}) is an anion with the two elements ____________ & ____________.

Silicates (SiO_x) are compound that is made of the elements ____________ & ____________. The "x" means that the number of oxygens can vary.

The "normal" version of the 5 main polyatomic anions (nitrate, carbonate, chlorate, sulfate, phosphate), all end in ___________. This is what you get from the normal Nick the Camel ☺

Weird Endings to Polyatomic Ions: The # of Oxygen Changes, BUT NEVER THE ____________!

If there is **1 extra oxygen atom**, the root—or main element—of the name (*nitr-, carbon-, sulf-, chlor-, phosph-*) is surrounded by PER_____ATE
If there is the "normal" number of carbons, it's what you already know: _____ATE

How to Remember:

Hey… are you super great?

If you've got an *extra oxygen*, then you're "**super great**" so use "***per-***" and "***-ate***"!

…Are you just great?

If you've got all of your *normal # of oxygens*, then you're just "**great**" so just use "***-ate***"!

Uh-oh… Now you have *fewer oxygens* than you normally have from Nick the Camel.

If there is **1 fewer oxygen**, the root is now surrounded by _____ITE.
If there are **2 fewer oxygens**, the root is now surrounded by HYPO_____ITE.

How to Remember:

Missing 1 oxygen? You're not great. You're just "***-ite***"

Missing 2 oxygens? You're less than "-ite." You're "***hypo____ite***"

(Hypo- means less than, lower than, under, below, decreased, *etc. Think: hypothermia, hypoglycemic)*

Purely Polyatomic Practice: *If you have the name, give the formula. If you have the formula, give the name.*

1) NO_3^- ____________________
2) Hyposulfite ____________________
3) NH_4^+ ____________________
4) PO_3^{3-} ____________________
5) Hypochlorite ____________________
6) Nitrite ____________________
7) Carbonate ____________________
8) PO_4^{3-} ____________________
9) Chlorate ____________________
10) SO_4^{2-} ____________________

REMEMBER: Polyatomic ions are like "packages" and "best friends forever," which means they travel together. The charge applies to the entire package. They do get into compounds with cations. **$NaNO_3$** is **sodium nitrate. $MgSO_4$** is **magnesium sulfate. Li_2CO_3** is **lithium carbonate. $Ca(ClO_3)_2$** is **calcium chlorate**… there are 2 "packages" of chlorate. Get it? Always make sure your (-) and (+) charges are balanced in the neutral compound!

Practice Quiz: Together as a class.

- Write the chemical formula for strontium sulfite. Sr^{2+} SO_3^{2-} $SrSO_3$
- What is ammonium? NH_4^+. It's positively charged, so it's a(n) cation, meaning it comes FIRST when you name something, even though it's not a metal.
  Write the chemical formula for ammonium chloride. NH_4Cl
- Write the chemical formula for sodium hydroxide. $NaOH$ Na^+ OH^-
- $Zn(NO_3)_2$ is zinc nitrate
- Vanadium(V) hydroxide is $V(OH)_5$. V^{5+} OH^-
- Write the chemical formula for ammonium hydroxide. ________
- Write the chemical formula for rubidium oxide. ________. Why doesn't rubidium have roman numerals in parentheses?
- Write the chemical formula for titanium(IV) oxide ________
- Dinitrogen pentasulfide is ________
- Xenon hexafluoride is ________
- Why is monocarbon disulfide an incorrect name?
- FeO and Fe_2O_3 are both iron oxide compounds. What is different about the irons in each compound?
- Why is tripotassium phosphate an incorrect ionic name?
- Lead(IV) oxide is PbO_2. Pb^{4+} O^{2-} → ~~Pb_2O_4~~ PbO_2

Assessment: MUST include oxidation state (roman numerals in parentheses) for transition metals when you write the name. All compounds are neutral, so do NOT include charges in your final answer on the line. Tip: Do the switchy thing, or do the reverse… depending on what you're doing.

1) Cobalt(II) nitrite $Co(NO_2)_2$ (Co^{2+} NO_2^-)
2) Phosphorus trichloride PCl_3
3) Ammonium bromide ________
4) Cesium selenide ________
5) Iron(II) perchlorate ________
6) Nitrogen disulfide ________
7) Diphosphorus tetroxide ________
8) Oxygen difluoride ________
9) Dinitrogen monoxide ________
10) Nickel(III) nitride NiN (Ni^{3+} N^{3-})
11) Fe_3N_2 ________
12) CdS ________
13) $Mg(ClO_4)_2$ magnesium perchlorate
14) NCl_3 ________
15) $Al(NO_3)_3$ ________
16) K_3PO_4 ________
17) CF_4 ________
18) SO_2 ________
19) TiN ________
20) W_2O_5 ________

Chapter 6 Part 2: Chemical Names and Formulas

A. Polyatomic Ions

1) A polyatomic ion is a group of covalently bonded atoms that carries a charge—in other words a charged molecule.

2) You need to memorize these eight: OH^-, NO_3^-, CO_3^{2-}, SO_4^{2-}, PO_4^{3-}, NH_4^+, $CH_3CO_2^-$, HCO_3^-

OH^- ____________________ NO_3^- ____________________

CO_3^{2-} ____________________ SO_4^{2-} = ____________________

PO_4^{3-} = ____________________ NH_4^+ ____________________

$CH_3CO_2^-$ ____________________ HCO_3^- ____________________

B. Names ↔Formulas for Polyatomic Ionic Compounds

1) Treat them just like binaries, except use parentheses when there is more than one polyatomic.

   Examples: $Mg(OH)_2$ $(NH_4)_2S$

2) Name to Formula Practice

   Potassium sulfate

   Aluminum nitrate

   Manganese(IV)carbonate

   Calcium hydroxide

   Ammonium phosphate

   Iron(III) acetate

3) Formula to name practice

$NaHCO_3$

$Sn(CO_3)_2$

$Cu(CH_3CO_2)_2$

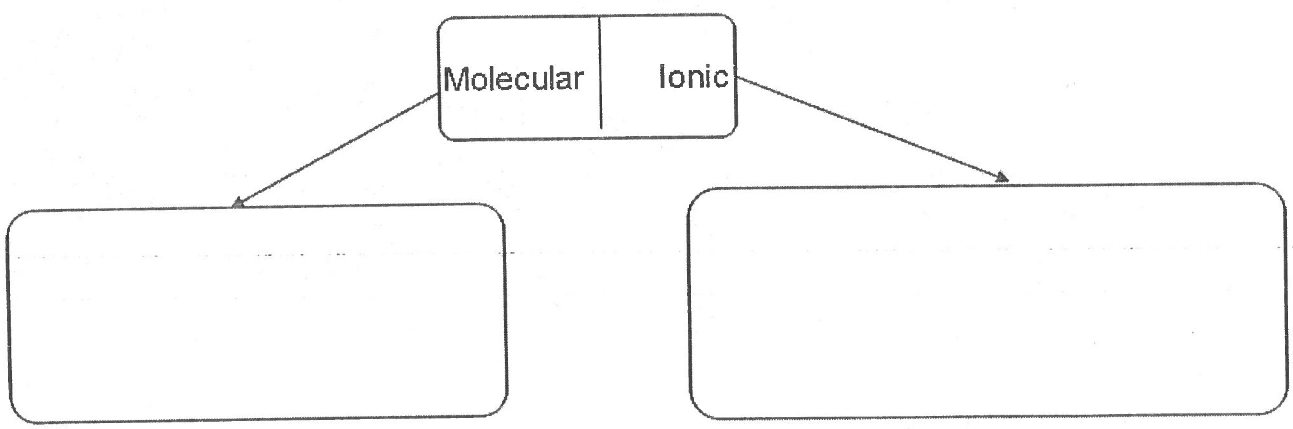
$Cr(SO_4)_3$

$(NH_4)_2CO_3$

$Mg(OH)_2$

Mixed Ionic and Molecular Naming

Formula to Name Flowchart



NH_4Cl

N_2O_5

$Pb(SO_4)_2$

SO_3

V_2O_5

$Zn(HCO_3)_2$

% comp by mass

Chapter Seven Part 2: Calculating Percent Composition of Elements in a Compound

Percent Composition: ***the percent by mass of an element in a compound***

Mg^{2+} O^{2-}

Experimental based problems

A 8.20 g piece of magnesium combines completely with 5.40 grams of oxygen to form a compound. What is the percent composition of magnesium in this compound?

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

★ Conservation of mass

8.20g + 5.40g → 13.60 g

$\% Mg = \frac{8.20g \text{ from Mg}}{13.60g \text{ total}} \times 100 = 60.3\% Mg$

When a 14.2 g sample of mercury(II) oxide is decomposed into its elements by heating, 13.2 g of Hg is obtained. What is the percent composition of oxygen in this compound?

$HgO \xrightarrow{\Delta} Hg + O_2(g)$

14.2g → 13.2g + 1.0 g

$\% \text{ Oxygen} = \frac{1.0g\ O_2}{14.2g \text{ total}} \times 100 = 7.0\%\ O_2$

Calculating Percent Composition from the Formula

Equation: % mass of element = $\frac{\text{total mass of the element in the compound}}{\text{molar mass of entire compound}} \times 100$

Find the percent composition of chlorine in iron(III) chloride $FeCl_3$

1×Fe (55.85)
+
3×Cl (3 · 35.45)

★ 162.20g/mol

$\% Cl = \frac{(3 \times 35.45)g}{162.20\ g} \times 100$ ← Cl, Cl, Cl / ← Fe, Cl, Cl, Cl

= 65.6 % Cl

Find the percent composition of oxygen in calcium nitrate

Ca^{2+} NO_3^- → $Ca(NO_3)_2$

1 Ca
2 N
6 Oxy

$\% Oxy = \frac{(6 \times 16.0)g}{164.0\ g}$ ← just all the oxys!!! / ← whole thing!!!

= 58.5 % O

What is the percent composition of sodium in sodium phosphate?

Na^{+} PO_4^{3-}

Na_3PO_4

$$\% Na = \frac{(23.0 + 23.0 + 23.0)\ g}{(23.0 + 23.0 + 23.0 + 31.0 + 16.0 + 16.0 + 16.0 + 16.0)\ g} \times 100$$

$= \sim 42\%$ Na

OYO Calculate the percent composition of nitrogen in ammonium oxide.

NH_4^{+} O^{2-} → $(NH_4)_2O$

$$\% N = \frac{28.0\ g\ N}{52.8\ g\ (NH_4)_2O} \times 100 = 53.0\%\ N$$

→ In which compound does carbon have a greater percentage of the composition by mass? Justify your answer mathematically.

CCl_4	☆ C_2F_2 ☆	Chromium(III) carbonate (Cr^{3+} CO_3^{2-}) $Cr_2(CO_3)_3$
$\% C = \frac{12.0}{153.8} \times 100$	$\% C = \frac{24}{62} \times 100$	$\% C = \frac{36}{284\ g} \times 100$
$= 7.8\%$ C	$= \sim 39\%$ C	$= \sim 13\%$ C

Ch 8 Part 2

Balancing equations with polyatomic ions involved—a short cut. still packaged!

Treat the polyatomics as a single unit if they are unchanged from the product to reactant side. Water can be treated as HOH.

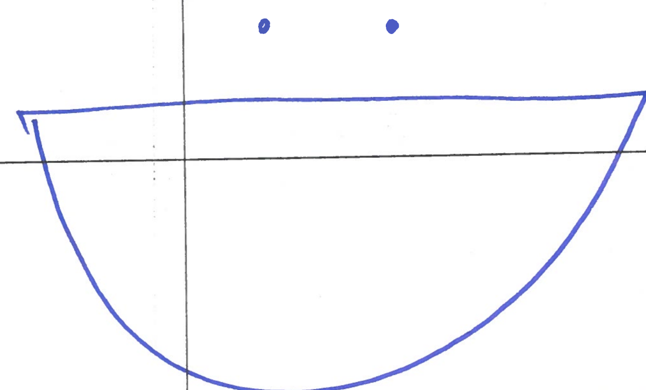
__2__ $AgNO_3$ + __1__ $Cu \rightarrow$ __1__ $Cu(NO_3)_2$ + __2__ Ag

__1__ K_3PO_4 + __1__ $Al(NO_3)_3 \rightarrow$ __3__ KNO_3 + __1__ $AlPO_4$

__1__ H_2SO_4 + __2__ $NaOH \rightarrow$ __1__ Na_2SO_4 + __2__ HOH

Chapter 8 Part 2: Reaction Types

Reaction type	General equation	Description	Unbalanced Examples
Single-replacement	$AX + Y \rightarrow YX + A$		$Fe + Cu(NO_3)_2 \rightarrow Fe(NO_3)_2 + Cu$ $Zn + HCl \rightarrow ZnCl_2 + H_2$ $AgNO_3 + Cu$□ $\rightarrow Cu(NO_3)_2 + Ag$ $Cl_2 + NaBr \rightarrow NaCl + Br_2$
Double-replacement	$AB + XY \rightarrow AY + XB$		$AgNO_3 + NaCl \rightarrow AgCl + NaNO_3$ $FeS + HCl \rightarrow FeCl_2 + H_2S$ $KOH + H_2SO_4 \rightarrow K_2SO_4 + H_2O$
Synthesis	$A + B \rightarrow AB$		$H_2 + O_2 \rightarrow H_2O$ $NO^+ NO \rightarrow N_2O_2$ $Fe + O_2 \rightarrow Fe_2O_3$ $2NO_2 \rightarrow N_2O_4$
Decomposition	$AB \rightarrow A + B$		$H_2O \rightarrow H_2 + O_2$ $MgCl_2 \rightarrow Mg(s) + Cl_2(g)$ $CaCO_3 \rightarrow CaO + CO_2$ $Ba(ClO_3)_2 \rightarrow BaCl_2 + O_2$
Combustion	$C_xH_yO_z + O_2 \rightarrow CO_2 + H_2O$		$CH_4 + O_2 \rightarrow CO_2 + H_2O$ $C_2H_6O + O_2 \rightarrow CO_2 + H_2O$



Chapter 9 Part 1: Introduction to Stoichiometry

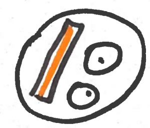
Interpreting a Chemical Equation: 

$2H_2O \rightarrow 2H_2 + O_2$

2 molecules of H_2O decomposes into 2 molecules of hydrogen and 1 molecule of oxygen

The recipe for Dr. Seuss Special

1 ~~ham~~ Bacon + 2 green eggs = 1 Dr. Seuss Special



Based on this recipe:

1) If I made 3 Dr. Seuss Specials, how many hams did I need?

$\frac{3\ DRS}{1} \times \frac{1\ hams}{1\ DRS} = 3\ hams$

2) If I made 8 Dr. Seuss Specials, how many green eggs did I need?

$\frac{8\ DRS}{1} \times \frac{2\ eggs}{1\ DRS} = 16\ eggs$

3) If I have 5 hams, how many green eggs to I need to use all the hams?

$\frac{5\ H}{1} \times \frac{1\ DRS}{1\ H} \times \frac{2\ eggs}{1\ DRS} = 10\ eggs$

4) If I have 30 green eggs, how many hams do I need to use all the eggs?

$\frac{30\ eggs}{1} \times \frac{1\ DRS}{2\ eggs} \times \frac{1\ hams}{1\ DRS} = 15\ hams$

5) If I have 4 hams and 300 green eggs, how many Dr. Seuss specials can I make?

excess

4 Dr. Seuss Specials

6) If I have 510 hams and 32 green eggs, how many Dr. Seuss specials can I make?

$\frac{32\ eggs}{1} \times \frac{1\ DRS}{2\ eggs} = 16\ specials$

Ratios!

→ rust

Mole Ratios

Here's an example of a chemical recipe: $4Fe + 3O_2 \rightarrow 2Fe_2O_3$

Based on the recipe (balanced equation) above:

a) If I have 1.0 mole of Fe with ~~excess oxygen~~, how many moles of Fe_2O_3 will I make?

$$4Fe + 3O_2 \rightarrow 2Fe_2O_3$$

~~27 slices~~
~~50 chicken~~

$$\frac{1.0\ mol\ Fe}{1} \times \frac{2\ mol\ Fe_2O_3}{4\ mol\ Fe} = 0.5\ mol\ Fe_2O_3$$

b) How many moles of oxygen will I need to react with 1.0 mole of Fe?

$$4Fe + 3O_2 \rightarrow 2Fe_2O_3$$

$$\frac{1\ mol\ Fe}{1} \times \frac{3\ mol\ O_2}{4\ mol\ Fe} = 0.75\ mol\ O_2$$

c) How many moles of Fe do I need to produce 6.0 moles of Fe_2O_3?

$$4Fe + 3O_2 \rightarrow 2Fe_2O_3$$

$$\frac{6.0\ mol\ Fe_2O_3}{1} \times \frac{4\ mol\ Fe}{2\ mol\ Fe_2O_3} = 12.0\ mol\ Fe$$

So, Stoichiometry is simply the calculation of quantities in reactions, and the key to Stoichiometry problems is the **MOLE RATIO** from the balanced equation. *Every Stoichiometry problem uses the* ***MOLE RATIO*** *from the balanced equation*

IIA Mole-Mole Calculations

How many moles of chlorine gas are needed to produce 0.0012 moles of HCl according to the reaction below?

$$2Cl_2(g) + 2H_2O(l) \rightarrow 4HCl(g) + O_2(g)$$

$$\frac{0.0012 \text{ mol HCl}}{1} \times \frac{2 \text{ mol } Cl_2}{4 \text{ mol HCl}} = 0.0006 \text{ or } 6 \times 10^{-4} \text{ mol } Cl_2$$

How many moles of oxygen are produced when 3.2 moles of HCl are made?

$$2Cl_2CO(g) \;\; 2H_2O(l) \rightarrow 4HCl(g) + 2CO(g) + O_2(g)$$

$$\frac{3.2 \text{ mol HCl}}{1} \times \frac{1 \text{ mol } O_2}{4 \text{ mol HCl}} = 0.8 \text{ mol } O_2$$

Given 6 moles of Aluminum, find the moles of copper produced.

$$3CuCl_2(aq) + 2Al(s) \rightarrow 2AlCl_3(aq) + 3\,Cu(s)$$

IIB Mole to Mass molar mass will be needed

Given 3.0 moles of Al and excess copper(II)chloride, how many grams of copper will be produced?

$$3CuCl_2(aq) + 2Al(s) \rightarrow 2AlCl_3(aq) + 3Cu(s)$$

$$\frac{3.0 \text{ mol Al}}{1} \times \frac{3 \text{ mol Cu}}{2 \text{ mol Al}} \times \frac{63.55 \text{ g Cu}}{1 \text{ mol Cu}} = 286 \text{ g Cu}$$

How many grams of water are needed to react with 0.15 moles of chlorine gas?

$$2Cl_2(g) + 2H_2O(l) \rightarrow 4HCl(g) + O_2(g)$$

$$\frac{0.15 \text{ mol } Cl_2}{1} \times \frac{2 \text{ mol } H_2O}{2 \text{ mol } Cl_2} \times \frac{18.0 \text{ g } H_2O}{1 \text{ mol } H_2O} = 2.7 \text{ g } H_2O$$

IIC Mole to Count (number of representative particle)

How many molecules of oxygen gas are needed to react completely with 40. moles of propanol (C_3H_6O)?

$$C_3H_6O + 4O_2 \rightarrow 3CO_2 + 3H_2O$$

mol C_3H_6O → mol O_2 → molecules O_2

$$\frac{40.\ \text{mol}\ C_3H_6O}{1} \times \frac{4\ \text{mol}\ O_2}{1\ \text{mol}\ C_3H_6O} \times \frac{6.02E23\ \text{molec.}\ O_2}{1\ \text{mol}\ O_2}$$

How many water molecules will be produced when 0.056 moles of oxygen are consumed?

$$C_3H_6O + 4O_2 \rightarrow 3CO_2 + 3H_2O$$

$$\frac{0.056\ \text{mol}\ O_2}{1} \times \frac{3\ \text{mol}\ H_2O}{4\ \text{mol}\ O_2} \times \frac{6.02E23\ \text{molec.}\ H_2O}{1\ \text{mol}\ H_2O}$$

=

10/17

10/18

IID Mole to Volume (22.4 L = 1 mol) @ STP $KE = \frac{1}{2}mv^2$

How many liters of oxygen gas are need to react completely with 13 moles of methane, CH_4 at STP?

$$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$$

$$\frac{13.0\ \text{mol}\ CH_4}{1} \times \frac{2\ \text{mol}\ O_2}{1\ \text{mol}\ CH_4} \times \frac{22.4\ L\ O_2}{1\ \text{mol}\ O_2}$$

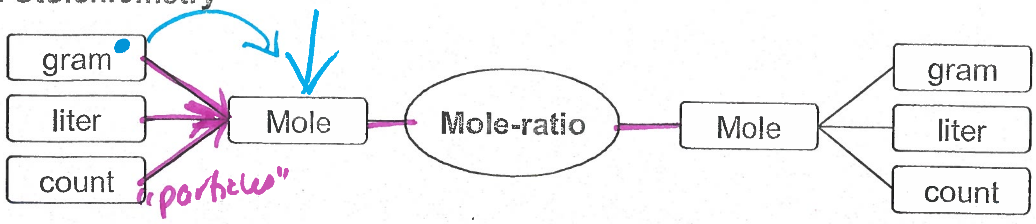
How many liters of oxygen gas will be produced from the decomposition of 2.0 moles of potassium chlorate? (oxygen candle reaction)

$$2KClO_3(s) \rightarrow 2KCl(s) + 3O_2(g)$$ oxidation

$$\frac{2.0\ \text{mol}\ KClO_3}{1} \times \frac{3\ \text{mol}\ O_2}{2\ \text{mol}\ KClO_3} \times \frac{22.4\ L\ O_2}{1\ \text{mol}\ O_2}$$

$= 67\ L\ O_2$

Mixed Stoichiometry



1. How many liters of oxygen will be needed to react completely with 58 grams of C_3H_8 at STP?

$$C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$$

$$\frac{58\ g\ C_3H_8}{1} \times \frac{1\ mol\ C_3H_8}{44\ g\ C_3H_8} \times \frac{5\ mol\ O_2}{1\ mol\ C_3H_8} \times \frac{22.4\ L\ O_2}{1\ mol\ O_2} = 150\ L\ O_2$$

OYO

2. How many liters of oxygen will react with 4.2 moles of phosphorus to form diphosphorus pentoxide at STP?

$$4P + 5O_2 \rightarrow 2P_2O_5$$

3. How many grams of iron will react with 562.2 grams of oxygen to form rust?

$$4Fe(s) + 3O_2(g) \rightarrow 2Fe_2O_3$$

$$\frac{562.2\ g\ O_2}{1} \times \frac{1\ mol\ O_2}{32.0\ g\ O_2} \times \frac{4\ mol\ Fe}{3\ mol\ O_2} \times \frac{55.85\ g\ Fe}{1\ mol\ Fe}$$

4. How many grams of phosgene, Cl_2CO, will produce 1.22 grams of hydrochloric acid, HCl, in the presence of excess water?

$$Cl_2CO + H_2O \rightarrow 2HCl + CO$$

g HCl → mol HCl → mol Cl_2CO → g Cl_2CO

use MM of HCl! use molar coefficients! use MM of Cl_2CO!

5. How many grams of iron(III) oxide (rust) are produced when 2.3 moles of oxygen reacts with iron?

(Ans = 240 g) $4Fe(s) + 3O_2(g) \rightarrow 2Fe_2O_3$

6. How many grams of carbon will react completely with $3x10^{21}$ molecules of S_8 to form carbon disulfide?

$$4C(s) + S_8(s) \rightarrow 4CS_2(g)$$

7. How many liters of oxygen will be needed to react with 0.42 moles of nitrogen to make dinitrogen pentoxide at STP?

$$2N_2 + 5O_2 \rightarrow 2N_2O_5$$

8. How many grams of butane, C_4H_{10}, are needed to react completely with 82 liters of oxygen at STP?

$$2C_4H_{10} + 13O_2 \rightarrow 8CO_2 + 10H_2O$$

9. How many liters of oxygen are required to react with 25.5 g of magnesium at STP?

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

10. How many molecules of ammonia are produced from 3.0 liters of hydrogen reacting with excess nitrogen at STP?

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

movement (of particles)

Chapter 10 Part 1: Gas Properties Skeleton Notes

Kinetic Theory: Particles in matter are constantly moving. (hotter means faster particle motion!)

$KE = \frac{1}{2}mv^2$

I. Kinetic Theory as applied to gases.

A) Gas particles have negligible volume compared to container size*
B) Gas particles do not attract or repel each other*
C) Gas particle move constantly, rapidly and randomly
D) All collisions perfectly elastic (particles collide like billiard balls, not marshmallows)

*key characteristics of "ideal gases"

II Gas pressure (units, atmospheric pressure, altitude and air pressure)

A) Gas pressure caused by billions of gas particles pushing against a container.

B) Units: SI unit: Kilopascal

C) Standard Temperature and Pressure (STP) = 0°C (= 273 K); 1 atm (sea level)

1. Other units (Pressure): 1 atm = 101.3 kPa = 760. mmHg = 760 torr = 14.7 psi (lbs/in²)

2. Converting between pressure units.

5.2 kPa = ? mmHg = 39 mmHg

$\frac{5.2\ kPa}{1} \times \frac{760\ mmHg}{101.3\ kPa}$

15 mmHg = ? atm

$\frac{15\ mmHg}{1} \times \frac{1\ atm}{760\ mmHg} = 0.02\ atm$

37.0 psi = ? torr = 1913 torr

$\frac{37.0\ psi}{1} \times \frac{760\ torr}{14.7\ psi}$

429.7 kPa = ? atm = ? psi = ? torr

$\frac{429.7\ kPa}{1} \times \frac{1\ atm}{101.3\ kPa} =$ atm

III Kinetic Energy and Kelvin temperature scale

A) When we measure temperature, we measure average kinetic energy (speed)

B) Gas particle's kinetic energy increases as temperature increases

C) Kelvin Temperature scale is absolute!!! Directly proportional to KE

273 K = 0 °C

D) Temperature note for working with gases. Convert C to K always!!!!!

$P_1V_1 = P_2V_2$

Chapter 12 Part 1: Boyles and Charles Law Skeleton Notes

I Variables Describing Gases

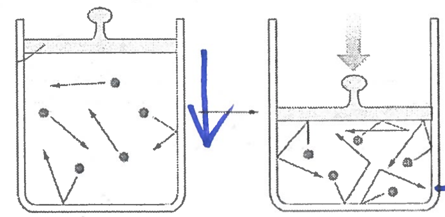
P = Pressure   V = Volume (L, mL, cm^3)

T = Temperature   n = # of moles

II Factors Affecting Gas Pressure

A) Changing the amount of gas particles in a closed container (n).
Doubling the number of gas molecules doubles pressure. Halving the number of molecules halves the pressure
Example: pumping up a playground ball   20 mol of air → 40 mol

B) Changing the container gas container volume (T and n stay constant)
Reducing the size of a container increases the gas pressure. Increasing the size decreases gas pressure.
Example: bicycle pump



pressure moves from H → L

C) Changing the temperature (V and n stay constant)
Increasing the temperature increases pressure. Why?

T↑, P↑

Example: aerosol can in fire

III The Gas Laws

A) **Boyle's Law (Volume-Pressure Change)** $P_1V_1 = P_2V_2$

1) Verbally: Volume varies inversely with pressure at a constant temperature.

2) Math Equation: $(101.3)(11) = V_2(85.3)$

Example 1: A balloon contains 11 L of He gas at 101.3 kPA (1 atm) at sea level. What is the balloon's volume in Denver at 85.3 kPa. (assume temperature is constant) $V_2 = 13.4$ L

$V_1 = 11$ L $P_1 = 101.3$ KPa   → $V_2 = ?$ L $P_2 = 85.3$ KPa

Example 2: If a piston compresses the air in a 0.52 Liter cylinder to 0.12 liters at 760 mm Hg. What will be the pressure in the cylinder after compression?

A) Charles's Law for Temperature-Volume Change

1) Verbally: The volume of a fixed mass of gas is directly proportional to its temperature (Kelvin) at constant pressure. $\frac{V_1}{T_1} = \frac{V_2}{T_2}$

2) Math Equation:

3) A balloon shrinks as it gets colder, and expands as it gets warmer.

Example 1: You buy a helium balloon for your friend's birthday. It has a volume of 8.0 liters in the store at 101.3 kPa and 20.°C. How large will the balloon be after you leave it sitting in your hot car at 60.°C?(pressure still = 101.3 kPa)

Example 2: Your friend takes the same balloon (8.0 liters at 20˚C and 101.3 kPa) with her to Antarctica where the balloon's volume shrinks to 6.9 liters at 101.3 kPa. How cold is it in Antarctica in Kelvins?(Ans = 253 K =______ with sig figs)

B) Gay-Lussac's Law (Pressure-Temperature Interaction)

1) Verbally: The pressure of a gas is directly proportional to its temperature (K)

2) Math Equation: $\frac{P_1}{T_1} = \frac{P_2}{T_2}$

3) Example 1: The tire pressure in a car's tires is 2.3 atmospheres (P_1) at 38°C ($\rightarrow$ 311 K T_1). What will the tire pressure be at -10.°C?

$T_2 \rightarrow 263$ K

4) Example 2: The pressure in a cylinder of gas is 760 mm Hg at exactly 0°C. What is the pressure of the gas at 500.°C?

Advanced Gas Law Practice:

1) The temperature of an unknown gas begins at 507 K, and is decreased so that the final temperature is 33.8% of the initial temperature. The pressure remains constant, but the volume changed. If the initial volume was 2.48×10^3 L, what is the final volume?

2) The final pressure of a gas is 240% of the initial pressure, which was 228.8 kPa. The volume of the gas remained *constant* at 857.6 cm^3. Determine the initial temperature if the final temperature was 1800 K.

3) A large spherical balloon, filled with helium, has a radius of 84.0 cm. A student then heats the balloon, increasing the temperature from 40.0°C to 98.0°. Assume that the pressure in the balloon remains constant as both the temperature and volume vary. He measured the radius before and after heating the balloon.
   a) Which variable is the independent variable? On which axis does it belong?

   b) Which variable is the dependent variable? On which axis does it belong?

   c) Calculate the initial (V_1) and final (V_2) volumes of the spherical balloon *with appropriate units*.

   d) Calculate the final radius of the spherical balloon in cm.