CHEM 115
Review for Exam 1

Lecture 9
Prof. Sevian

1

Agenda

- More practice with writing net ionic equations
- Rules about test taking in Chem 115
  - Read the info on the website
  - Sit every other seat, every other row
  - You should bring a calculator and pencil (not pen)
  - Scratch paper will be provided
  - The exam is from 2:00-3:15
  - The exam ends at 3:15
- Review for Exam 1, which is this Thursday

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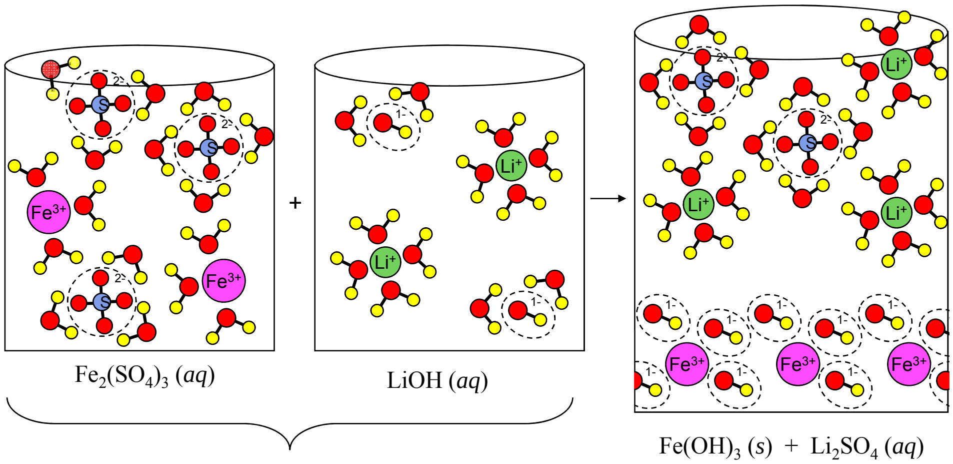
What is a net ionic equation?

$Fe_2(SO_4)_3\ (aq) + 6\ LiOH\ (aq) \rightarrow 2\ Fe(OH)_3\ (s) + 3\ Li_2SO_4\ (aq)$



These are the reactants

These are the products

(Note: ratios of ions in solution is not to scale because the pictures wouldn't fit)

Practice writing another net ionic equation

- What is the net ionic equation that occurs when a solution of sodium sulfide is combined with a solution of silver nitrate?

$Na_2S\ (aq)\ +\ AgNO_3\ (aq)$

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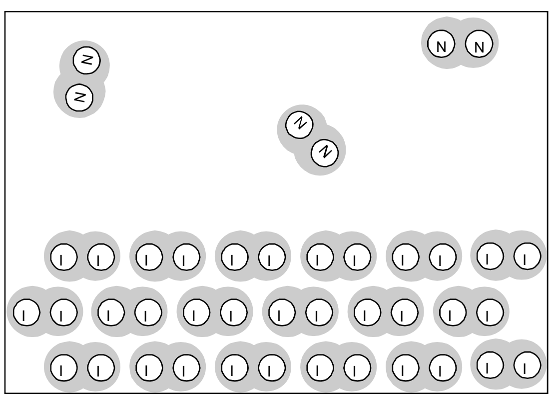
Review for Exam 1

- Classifying matter
- Density as an example of an intensive property
  - Calculating density
  - Significant figures
- Conversions
  - Dimensional analysis as a technique for solving problems
  - Types of conversions we have used:
    - Using density to convert between g and cm^3 (or mL)
    - Using molar mass to convert between g and mol
    - Using Avogadro's number to convert between moles and molecules (or atoms or units of ionic formula)
    - Using stoichiometric coefficient ratios to convert between one kind of chemical and another

Practice

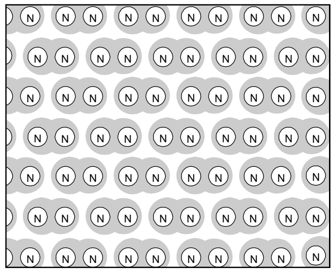


Pure substance or mixture?

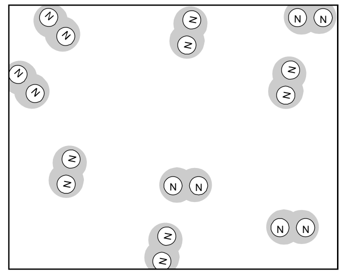
Element or Compound?

Homogeneous or Heterogeneous?

Density = A measure of concentration



N_2 (*s*)



N_2 (*g*)

Which is more dense, the solid or the gas?

Density measures how many particles (how much "stuff") are in a given volume (space). To compare two samples, you can either:

- **Compare equal volumes and then see which one has more particles (stuff) in that same volume (space)**
- **Compare equal amounts of particles (stuff) and see which one takes up more volume (space)**

Example: Density Problem

Mercury has a density of 13.534 g/mL. What is the mass of 24 mL of mercury?

Mass units are grams

Start

End

$$\frac{24\ \text{mL}}{} \times \frac{13.534\ \text{g}}{1\ \text{mL}} = 320\ \text{g}$$

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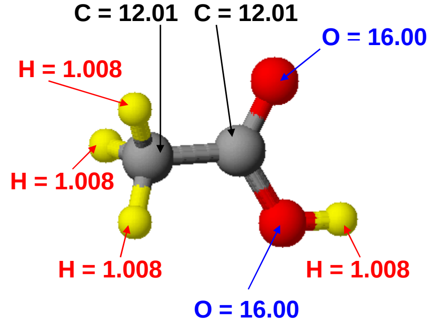
Using Molar Mass as a Conversion

What is the mass of 0.00497 mol of CH_3COOH?



Molar mass = 60.05 g/mol

$$0.00497\ mol\ \mathrm{CH_3COOH} \times \frac{60.05\ g}{1\ mol} = 0.298\ g\ \mathrm{CH_3COOH}$$

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How Many Molecules?

Too many to count!

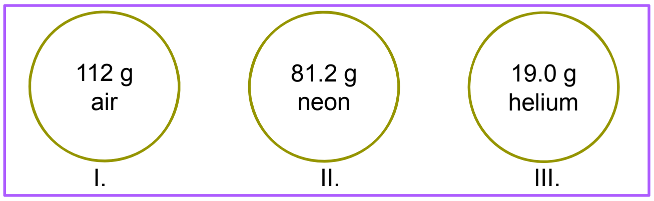
How many molecules of water are in a 2.00-L bottle that is filled with water? Water has a density of 1.000 g/mL.

Start **End**

$$\frac{2.00\ \mathrm{L\ of\ H_2O}}{1} \times \frac{1000\ mL}{1\ L} \times \frac{1.000\ g}{1\ mL} \times \frac{1\ mol}{18.02\ g} \times \frac{6.022\times10^{23}\ molecules}{1\ mol} = \frac{6.68\times10^{25}\ \mathrm{molecules\ of\ H_2O}}{1}$$

Clicker question #1

Each container has the same volume of gas at the same temperature and pressure. However, each container has a different gas in it.



Which flask has the gas with the greatest density?

A) I.
B) II.
C) III.
D) They are all the same density.

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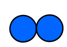
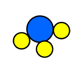
Stoichiometry problem for the reaction:

$$N_2 + 3\,H_2 \rightarrow 2\,NH_3$$

2.06 grams of 

excess of 

How many grams of this will be produced? 

	N_2	H_2	NH_3
Before	2.06 g N_2 $2.06\,g\,N_2 \times \frac{1\,mol\,N_2}{28.02\,g\,N_2} = 0.0735\,mol\,N_2$	excess	none
Change	- 0.0735 mol N_2	*you could figure out how much if you wanted to*	$0.0735\,mol\,N_2 \times \frac{2\,mol\,NH_3}{1\,mol\,N_2} = 0.147\,mol\,NH_3$
After	none	some	$0.147\,mol\,NH_3 \times \frac{17.03\,g\,NH_3}{1\,mol\,NH_3} = 2.50\,g\,NH_3$

Clicker question #2

A flask is prepared with 15.0 g of NO and 16.0 g of O_2. If the following reaction were to occur,

$$2\ NO + O_2 \rightarrow 2\ NO_2$$

which reactant would be the limiting one?

Compound	NO	O_2	NO_2
Molar mass ($g{\cdot}mol^{-1}$)	30.0	32.0	46.0

A) NO would be the limiting reactant
B) O_2 would be the limiting reactant
C) NO_2 would be the limiting reactant
D) Neither reactant would be limiting
E) Both reactants would be limiting

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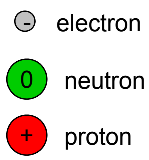
Review for Exam 1

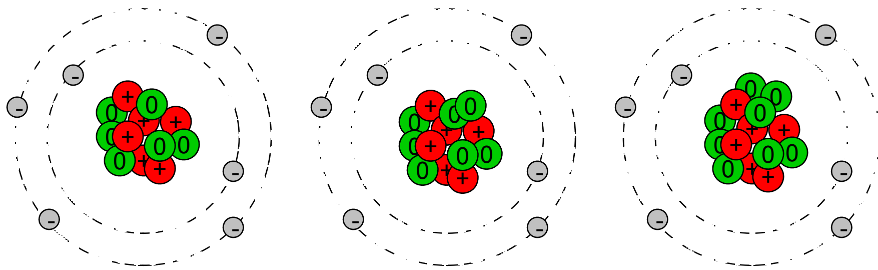
- How can atoms of the same element vary?
  - Isotopes have different quantities of neutrons, but they have the same quantities of protons and electrons
  - How to write an isotope symbol
  - What the numbers inside the boxes on the periodic table mean
- Most of chemistry is about electrons
  - When a neutral atom gains electrons, it becomes negatively charged
    - Nonmetals do this (and you can figure out the charge from the Pd Table)
    - There are lots of negatively charged nonmetal polyatomic ions
    - There are some negatively charged polyatomic ions which have metal innards with oxygen bonded (e.g. $Cr_2O_7^{2-}$, MnO_4^-)
  - When a neutral atom loses electrons, it becomes positively charged
    - Metals do this (and for non-transition metals you can figure out the charge from the Pd Table)
    - Many transition metals can lose different amounts of electrons
    - Occasionally you have positively charged polyatomic ions (e.g., NH_4^+)
- Chemical nomenclature
  - First figure out if a compound is ionic, molecular or acid
  - Then use naming rules for that kind of compound



How Can the Nucleus Vary?

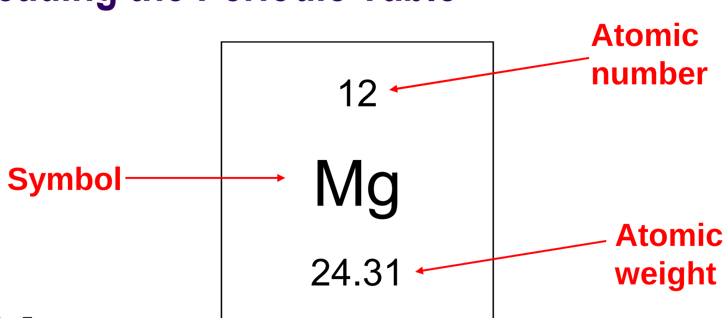
Three different <u>isotopes</u> of carbon atoms

(Note: Bohr model is incorrect, but very useful)



Same	All have 6 electrons	All have 6 protons	All neutral
Different	6 neutrons	7 neutrons	8 neutrons
Symbol	${}^{12}_{6}\mathrm{C}$	${}^{13}_{6}\mathrm{C}$	${}^{14}_{6}\mathrm{C}$

Reading the Periodic Table



${}^{24}_{12}\mathrm{Mg}$ ← A neutral isotope of magnesium

A +2 charged ion of the magnesium-25 isotope → ${}^{25}_{12}\mathrm{Mg}^{2+}$

${}^{25}_{12}\mathrm{Mg}$ ← A different neutral isotope of magnesium

A +2 charged ion of magnesium (with no information about which isotope, so you have to conclude that it is a common sample of magnesium ions and all isotopes are present in their naturally occurring abundances) → Mg^{2+}

Clicker question #3

Which is correct for a +2 charged ion of ${}^{89}_{38}\mathrm{Sr}$?

	protons	neutrons	electrons
A)	38	89	38
B)	38	51	38
C)	38	51	36
D)	38	51	40
E)	Not enough information to tell		

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Overview of chemical nomenclature (1)

- Given the formula, to figure out the name
  - First figure out if it's ionic, molecular, or an acid, then name according to one of the following rules:

1. Ionic
   - Distinguish the two ions – this will usually involve figuring out their charges
   - First name = positive ion, Last name = negative ion
     - Transition metals need ionic charge given as part of name (you have to say which one since they can take more than one possible charge)
2. Molecular
   - Primarily you will need to know water, ammonia and the first 10 alkanes
   - Otherwise, First name = (prefix)element, Last name = (prefix)element-ide
3. Acid
   - Break down as if it were an ionic compound, H^+ is always the positive ion
   - First name = derived from negative ion, Last name = acid

Overview of chemical nomenclature (2)

- Given the name, to figure out the formula
  - First figure out if it's ionic, molecular, or an acid, then determine the formula according to one of the following methods:

1. Ionic
   - First name = positive ion, Last name = negative ion
   - Figure out what the formulas of the ions and their charges are
   - Determine the smallest ratio of ions to make a neutral compound
2. Molecular
   - Primarily you will need to know water, ammonia and the first 10 alkanes
3. Acid
   - First name = derived from negative ion, Last name = acid (means H^+)
   - Figure out the formula and charge on the negative ion is
   - Determine the ratio of H^+ and the negative ion to make a neutral compound

If the compound is neutral, do not write charges in the chemical formula

i-clicker

Clicker question #4

Which answer has the correct classifications for knowing which naming rules to use for the compounds?

	H_2CO_3	Na_2CO_3	C_2H_5OH
A)	Acid	Ionic	Molecular
B)	Ionic	Molecular	Acid
C)	Molecular	Acid	Ionic
D)	Not enough information to tell		

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Review for Exam 1

- Chemical formulas
  - Calculating molar mass
  - Mass ↔ moles conversions
- Composition is percent (parts of 100) by mass
  - Elements in a compound (C, H and O in acetic acid, CH_3COOH)
  - Compounds in a hydrated ionic compound (e.g., $CuSO_4 \bullet 5H_2O$)
  - Compounds in a mixture (ingredients in baking powder)
- Determining empirical formula (smallest integer ratio of moles in a formula)
  - Simplifying a formula (e.g., $C_6H_{12}O_6$ has empirical formula CH_2O)
  - Starting with percent composition (or mass composition)
- Determining molecular formula
  - Must be given enough information to get two things:
    - Empirical formula (can be given or can get from mass %)
    - Molecular mass (need to compare this to empirical mass)

Hydrated Ionic Compounds

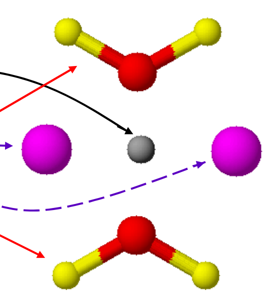
How many moles are in 5.55 g of $BaCl_2 \cdot 2H_2O$?

One unit of ionic formula consists of:

One Ba^{2+} ion = 137.3

Two Cl^- ions = 2 × 35.45

Two H_2O molecules = 2 × 18.02



Formula weight = 244.2 g/mol

$$5.55\ g\ \mathrm{BaCl_2 \bullet 2H_2O} \times \frac{1\ mol}{244.2\ g} = 0.0227\ mol\ \mathrm{BaCl_2 \bullet 2H_2O}$$

Composition of a Compound

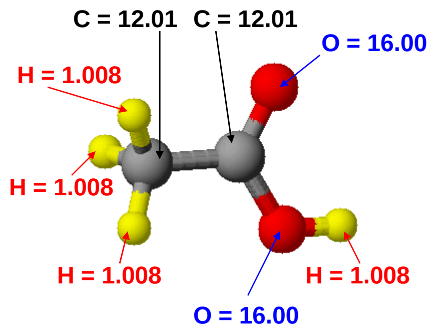
What is the composition by mass of acetic acid (CH_3COOH)?

$$\%C = \frac{24.02}{60.05} \times 100\% = 40.00\%$$

$$\%H = \frac{4.032g}{60.05g} \times 100\% = 6.714\%$$

$$\%O = \frac{32.00g}{60.05g} \times 100\% = 53.29\%$$

$$Check: 40.00 + 6.714 + 53.29 = 100.00\%$$



Recall from earlier:
Molar mass = 60.05 g/mol

Composition of a Hydrated Compound

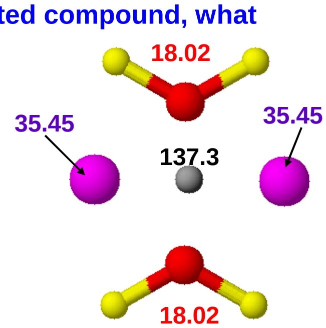
Heating barium chloride dihydrate ($BaCl_2 \bullet 2H_2O$) drives off the water, leaving the anhydrous compound ($BaCl_2$). The chemical reaction is

$$BaCl_2 \bullet 2H_2O\ (s) \rightarrow BaCl_2\ (s) + 2\ H_2O\ (g)$$

If you begin with a 10.0 g sample of the hydrated compound, what mass of water will be lost?

$$\%H_2O = \frac{2 \times 18.02}{244.2} \times 100\% = 7.379\%$$

$$\begin{aligned} \text{mass of } H_2O \text{ in sample} &= 7.379\% \text{ of } 10.0\ g \\ &= 0.07379 \times 10.0g \\ &= 0.738g \end{aligned}$$



Formula weight = 244.2 g/mol

Composition of a Mixture

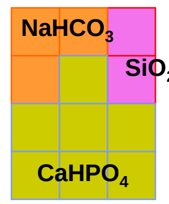
Baking powder is a mixture of ingredients. A sample of baking powder contains 3.50 g of calcium hydrogen phosphate ($CaHPO_4$), 1.50 g of sodium bicarbonate ($NaHCO_3$), and 1.00 g of silicon dioxide (SiO_2). Calculate the percent composition by mass.

$$\%\mathrm{CaHPO_4} = \frac{3.50g}{3.50+1.50+1.00g}\times 100\% = 58.3\%$$

$$\%\mathrm{NaHCO_3} = \frac{1.50g}{6.00g}\times 100\% = 25.0\%$$

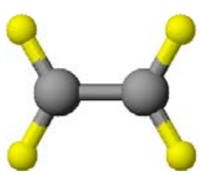
$$\%\mathrm{SiO_2} = 100-(58.3+25.0)\% = 16.7\%$$

A picture of the mixture (to assist in estimating)

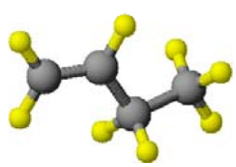


Molecular Formula to Empirical Formula

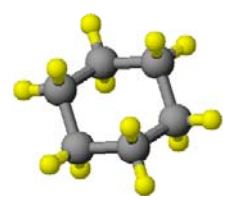
- What are the empirical formulas of these compounds?



C_2H_4



C_4H_8



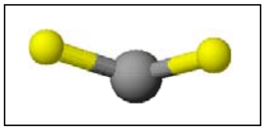
C_6H_{12}

- All three of these compounds have 85.63% carbon, and 14.37% hydrogen by mass

Empirical Formula to Molecular Formula

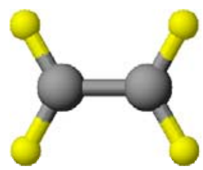
To do this, you must be given two pieces of information:

1) Information that will get you to the empirical formula
2) The molecular mass



Empirical Unit CH_2

Mass is 12.01 + 2(1.008) = 14.03 g/mol

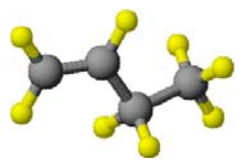


C_2H_4

2 × (CH_2)

= 2 × (14.03)

= **28.06 g/mol**

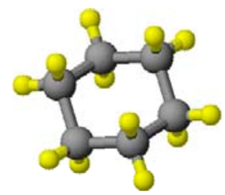


C_4H_8

4 × (CH_2)

= 4 × (14.03)

= **56.12 g/mol**



C_6H_{12}

6 × (CH_2)

= 6 × (14.03)

= **84.18 g/mol**

Clicker question #5

i-clicker

A student solved the following problem and made a critical mistake. What is the mistake?

Problem:

Analysis of 0.500 g of an unknown chemical revealed that it contained 0.200 g of carbon, 0.034 g of hydrogen, and the rest oxygen. What is the empirical formula?

Student's work:

Empirical formula is C $\left(\frac{0.200}{0.034}\right)$ H $\left(\frac{0.034}{0.034}\right)$ O $\left(\frac{0.266}{0.034}\right)$

Simplifies to: $C_6H_1O_8$

A) The student calculated the amount of oxygen incorrectly.
B) The student rounded improperly on the subscripts.
C) The student made a ratio of mass instead of moles.
D) The student should have divided all the numbers by 0.500 first.

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Review for Exam 1

- Chemical reactions
  - Types of reactions: combustion, precipitation, and others
  - Predicting products: need to first figure out what kind of reaction it is
    - If it is an exchange reaction, then reactant ionic compounds switch partners
      - Remember to write the positive ion first in ionic compounds
      - Remember to make neutral compounds
  - Balance a chemical equation by conservation of matter
    - You can only do stoichiometry calculations with balanced reactions
- Stoichiometry calculations
  - When you are told (sometimes implicitly) that one reactant is in excess
  - When you are given both reactants and have to figure out which one is limiting

Chemical Equations

- Represent a chemical change of matter
- Reactants (starting materials) on left
- Products (ending materials) on right

Reactants $\rightarrow$ Products

- What goes in must come out, just connected (bonded) differently

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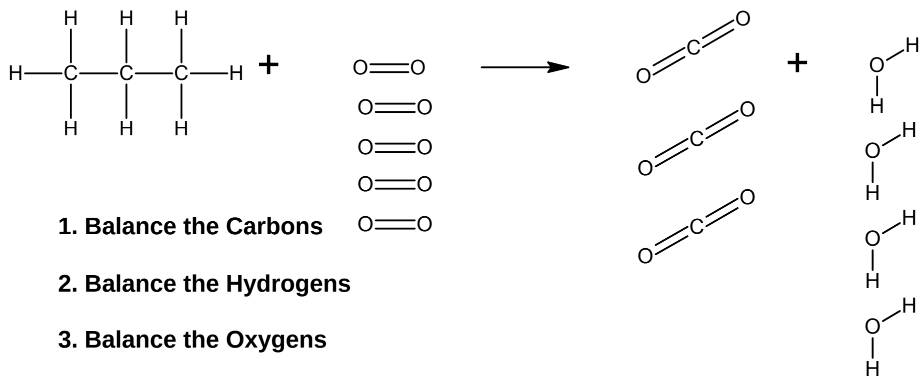
Combustion of propane



1. **Balance the Carbons**
2. **Balance the Hydrogens**
3. **Balance the Oxygens**
4. **Is it balanced?**

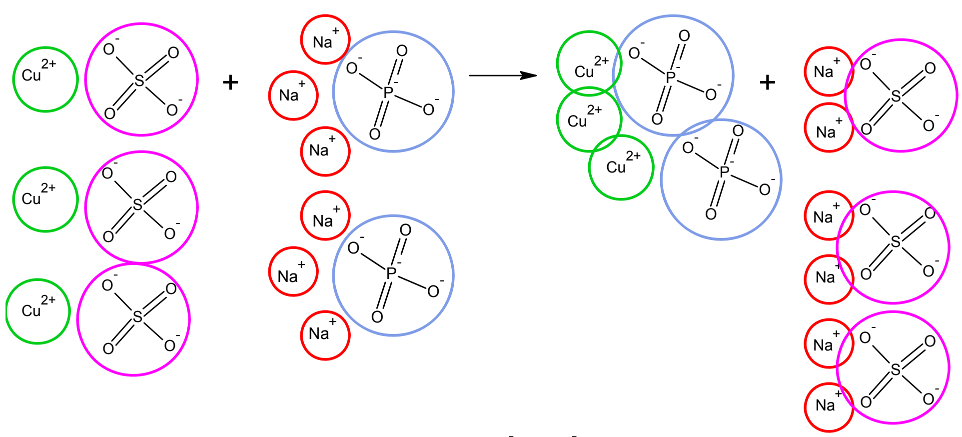
Balanced chemical equation:

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

When the balancing units are ions, not atoms

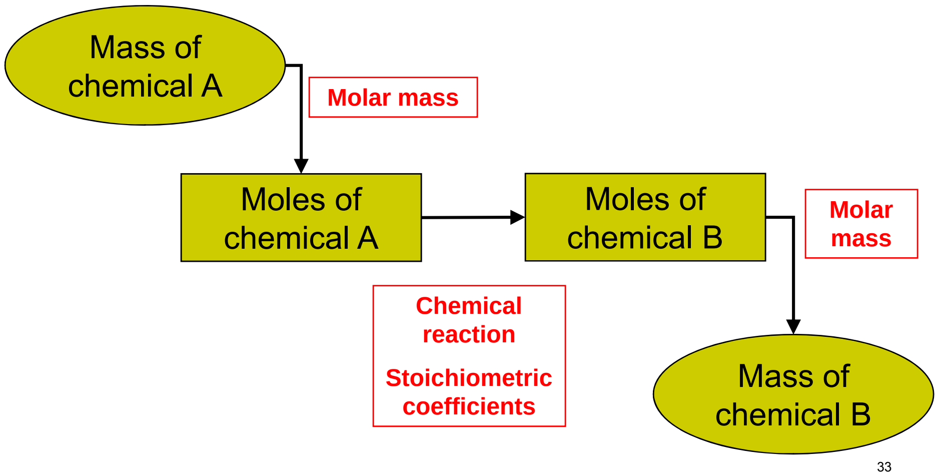
Another reason why it's important to know how to name chemicals: so you can identify the ions to balance reactions that involve ions

$CuSO_4 + Na_3PO_4 \rightarrow Cu_3(PO_4)_2 + Na_2SO_4$

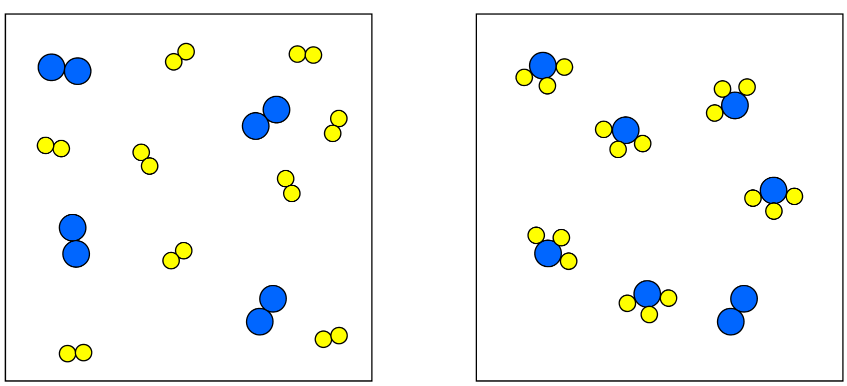


$3\ CuSO_4 + 2\ Na_3PO_4 \rightarrow Cu_3(PO_4)_2 + 3\ Na_2SO_4$

General Strategy for Simple Stoichiometry Problems



Stoichiometry (counting atoms) of $N_2 + 3\ H_2 \rightarrow 2\ NH_3$



	N_2	H_2	NH_3
Before	4 mol	9 mol	0 mol
Change	*-3 mol*	*-9 mol*	*+6 mol*
After	1 mol	0 mol	6 mol

Review for Exam 1

- Precipitation reactions
  - These are exchange reactions
  - When predicting the products that result from mixing two solutions containing ionic compounds, key is to figure out whether one (or both) product is insoluble, and hence precipitates out of solution
  - Don't forget to form neutral compounds on the product side
- Writing net ionic equations
  - Shows the "net" of what is reacting
    - Spectator ions are omitted because they do not participate
    - Ok to write ions because it is understood that these are ions dissolved water
    - Only ionic compounds that are soluble break into ions, everything else remains whole (i.e., precipitates, gases, reactants that start as solids)
  - You're learning how to write these for precipitation reactions, but you will also need to write them for other kinds of reactions soon

Solubility guidelines

How to read this table:
If one ion from the "Soluble Compounds" list is in an ionic compound, then a lot of the ionic compound can dissolve in water.

Likewise, if one ion from the "Insoluble Compounds" list is in an ionic compound, then the ionic compound will not dissolve very much in water.

TABLE 4.1 Solubility Guidelines for Common Ionic Compounds in Water

Soluble Ionic Compounds		Important Exceptions
Compounds containing	NO_3^-	None
	$C_2H_3O_2^-$	None
	Cl^-	Compounds of Ag^+, Hg_2^{2+}, and Pb^{2+}
	Br^-	Compounds of Ag^+, Hg_2^{2+}, and Pb^{2+}
	I^-	Compounds of Ag^+, Hg_2^{2+}, and Pb^{2+}
	SO_4^{2-}	Compounds of Sr^{2+}, Ba^{2+}, Hg_2^{2+}, and Pb^{2+}
Insoluble Ionic Compounds		**Important Exceptions**
Compounds containing	S^{2-}	Compounds of NH_4^+, the alkali metal cations, and Ca^{2+}, Sr^{2+}, and Ba^{2+}
	CO_3^{2-}	Compounds of NH_4^+ and the alkali metal cations
	PO_4^{3-}	Compounds of NH_4^+ and the alkali metal cations
	OH^-	Compounds of the alkali metal cations, and NH_4^+, Ca^{2+}, Sr^{2+}, and Ba^{2+}

Clicker question #6

Which of the following salts would be least soluble in water?

A) $CaCO_3$
B) Na_2CO_3
C) $CaBr_2$
D) $AgBr$
E) $AgNO_3$

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Clicker question #7

What would be the products if you mixed a solution of $Pb(C_2H_3O_2)_2$ with a solution of KOH?

A) PbK (*s*) and $C_2H_3O_2OH$ (*aq*)
B) $KC_2H_3O_2$ (*aq*) and $Pb(OH)_2$ (s)
C) PbOH (*s*) and $KC_2H_3O_2$ (*aq*)
D) $HC_2H_3O_2$ (*aq*) and KOPb (*s*)
E) No reaction would occur

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