CHEM 200/202

Professor Greg Holland
Office: GMCS-213C

All emails are to be sent to:
chem200@sdsu.edu

My office hours will be held on **Zoom Monday from 12 to 2 pm** or by appointment.

SUPPLEMENTAL INSTRUCTION (SI)

- Study sessions lead by former CHEM 200/202 students that excelled in the previous semesters class.
- Occur 15+ times a week.
- Free to access, no reporting to faculty.

IMPORTANT ANNOUNCEMENTS

- Only email chem200@sdsu.edu -- Theresa is still get surprising number of emails at tcarlson@sdsu.edu (which she doesn't even look at or use). She has stopped reading emails unless they are emailed to chem200@sdsu.edu.

- Check that you know which version letter you have for Exam 1. You need to go to Blackboard > (left hand side) Exam Groups > and you should see the exam group and inside is the password and a picture of the page before the exam with some useful troubleshooting tips.

- For the exam you need to use chrome, have cleared your cache and cookies before you start, turn off ad blockers, AND don't open up any tabs. FYI opening up tabs will speed up their timer for the exam. It's a bug that has yet to be resolved by Cengage. You will need to print from the Course Documents on the Chem 200 website: the periodic table, solubility chart, and the exam sheet. This way you have the information in front of you. Also, using other outside resources will lead to errors in their calculations or even wrong answers.

- Theresa is uploading OWL Labs and Hayden McNeil grades Tues/Wed into Blackboard. If they see a zero they didn't follow my directions that I sent several announcements about. They will have until **Friday, February 19th at 5:00 PM** to email me there was an issue otherwise the grades will stay as zeros.

EXAM 1 REVIEW

Chapters 1-4

CHAPTER 1

- Describe the scientific method.
- Describe the different classifications of matter.
- Differentiate between physical & chemical changes.
- Define SI units.
- Differentiate between accuracy and precision.

SI UNITS

The rational units of measurement.

Dimension	Unit name	Abbreviation
Mass	kilogram	kg
Length	meter	m
Time	second	s
Temperature	kelvin	K
Electric current	ampere	A
amount of substance	mole	mol
luminous intensity	candela	cd

SCIENTIFIC NOTATION & PREFIXES

Prefix	Symbol	Word	Conventional	Scientific
-	-	one	1	1×10^{0}
deci	d	tenth	0.1	1×10^{-1}
centi	c	hundredth	0.01	1×10^{-2}
milli	m	thousandth	0.001	1×10^{-3}
micro	μ	millionth	0.000001	1×10^{-6}
nano	n	billionth	0.000000001	1×10^{-9}
pico	p	trillionth	0.000000000001	1×10^{-12}
femto	f	quadrillionth	0.000000000000001	1×10^{-15}

SCIENTIFIC NOTATION & PREFIXES

Prefix	Symbol	Word	Conventional	Scientific
tera	T	trillion	1,000,000,000,000	1×10^{12}
giga	G	billion	1,000,000,000	1×10^{9}
mega	M	million	1,000,000	1×10^{6}
kilo	k	thousand	1,000	1×10^{3}
hecto	h	hundred	100	1×10^{2}
deka	da	ten	10	1×10^{1}
-	-	one	1	1×10^{0}

MATH & SIGNIFICANT FIGURES

Addition & Subtraction

$$\begin{array}{r} 83.5 \text{ mL} \\ +\ 23.28 \text{ mL} \\ \hline 106.78 \text{ mL} \end{array} = 106.8 \text{ mL}$$

$$\begin{array}{r} 865.90 \text{ g} \\ -\ 2.8121 \text{ g} \\ \hline 863.0879 \text{ g} \end{array} = 863.09 \text{ g}$$

Multiplication & Division

$$\begin{array}{r} 15.6 \text{ cm} \\ \times\ 6.023 \text{ cm} \\ \times\ 0.34 \text{ cm} \\ \hline 31.945992 \text{ cm}^3 \end{array} = 32 \text{ cm}^3$$

15.6 cm ← 3 sig figs

6.023 cm ← 4 sig figs

0.34 cm ← 2 sig figs

$$\begin{array}{r} 500 \text{ g} \\ \div\ 305.4 \text{ mL} \\ \hline 1.6371971 \text{ g/mL} \end{array}$$

$$= 2 \text{ g/mL}$$

ERRORS IN MEASUREMENTS

- Random error: ALL measurements have some level of random error, they can be either positive or negative errors.

- Systematic error: arise from problems in the measurement procedure, they will be either positive or negative, but not both.

- Systematic errors will also be subject to random error; there will be variations in replicate measurements that have systematic error.

PRECISION & ACCURACY

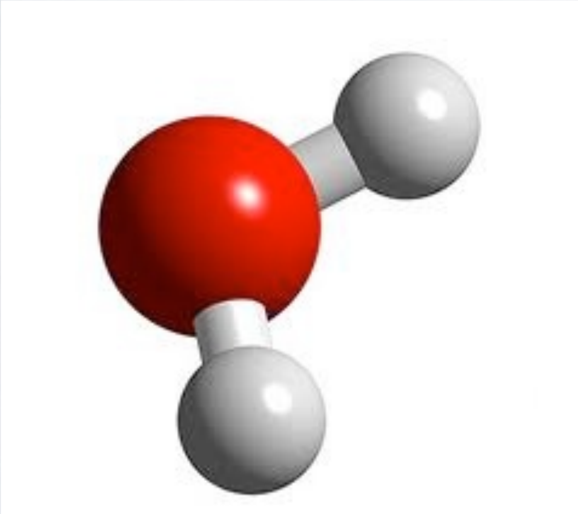
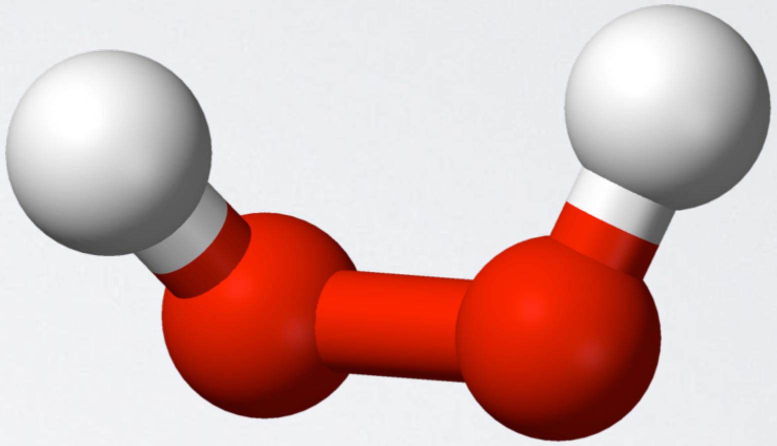
- Precision relates to how reproducible each measurement is; how close each measurement is to the other measurements.

- Accuracy relates to how close the measured values are to the true value.

CHAPTER 2

- Describe atomic theory and its evolution
- Calculate isotopic abundances.
- Interpret molecular formulas.
- Differentiate between empirical and molecular formulas.
- Calculate the empirical formula from given masses of elements.
- Identify metals, nonmetals, and metalloids by their position on the periodic table.
- Predict properties of elements based on their location on the periodic table.
- Differentiate between ionic and covalent compounds.
- Determine if a molecule is ionic or covalent based on its molecular formula.
- Translate between molecular formulas and the names of common ionic and covalent compounds.

WATER VS. HYDROGEN PEROXIDE

Water		Hydrogen Peroxide
		
H_2O	Molecular Formula	H_2O_2
H_2O	Empirical Formula	HO
HOH	Structural Formula	HOOH

Periodic Table of the Elements

Metals

Metalloids

Non-Metals

Transition Metals

	1	2		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1 H 1.008																		2 He 4.003
2	3 Li 6.941	4 Be 9.012												5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
3	11 Na 22.99	12 Mg 24.31												13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95
4	19 K 39.10	20 Ca 40.08		21 Sc 44.96	22 Ti 47.87	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.39	31 Ga 69.72	32 Ge 72.64	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80
5	37 Rb 85.47	38 Sr 87.62		39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc [98]	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	48 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3
6	55 Cs 132.9	56 Ba 137.3	57-70 *	71 Lu 175.0	72 Hf 178.5	73 Ta 180.9	74 W 183.8	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.1	79 Au 197.0	80 Hg 200.6	81 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po [209]	85 At [210]	86 Rn [220]
7	87 Fr [223]	88 Ra [226]	89-102 **	103 Lr [262]	104 Rf [261]	105 Db [262]	106 Sg [266]	107 Bh [264]	108 Hs [277]	109 Mt [268]								Metals	Non Metals

* Lanthanoids	57 La 138.9	58 Ce 140.1	59 Pr 140.9	60 Nd 144.2	61 Pm [145]	62 Sm 150.4	63 Eu 152.0	64 Gd 157.3	65 Tb 158.9	66 Dy 162.5	67 Ho 164.9	68 Er 167.3	69 Tm 168.9	70 Yb 173.0
** Actinoids	89 Ac [227]	90 Th 232.0	91 Pa 231.0	92 U 238.0	93 Np [237]	94 Pu [244]	95 Am [243]	96 Cm [247]	97 Bk [247]	98 Cf [251]	99 Es [252]	100 Fm [257]	101 Md [258]	102 No [259]

CHEMICAL BONDING

- Bonds form between atoms when they share electrons.
- Not all atoms share electrons in the same way; some are "generous" others are "selfish".
- The types of atoms forming the bond define the type of bond.
- **Ionic compounds** - metal + non-metal - electrons transferred to one element from the other.
- **Covalent compounds** - non-metals only - electrons are shared between atoms.

NAMING COVALENT COMPOUNDS

PCl_3 - Phosphorous trichloride   Both non-metals

The naming convention specifies the relative number of atoms - there may more than one possible ratio of atoms

PCl_5 - Phosphorous pentachloride

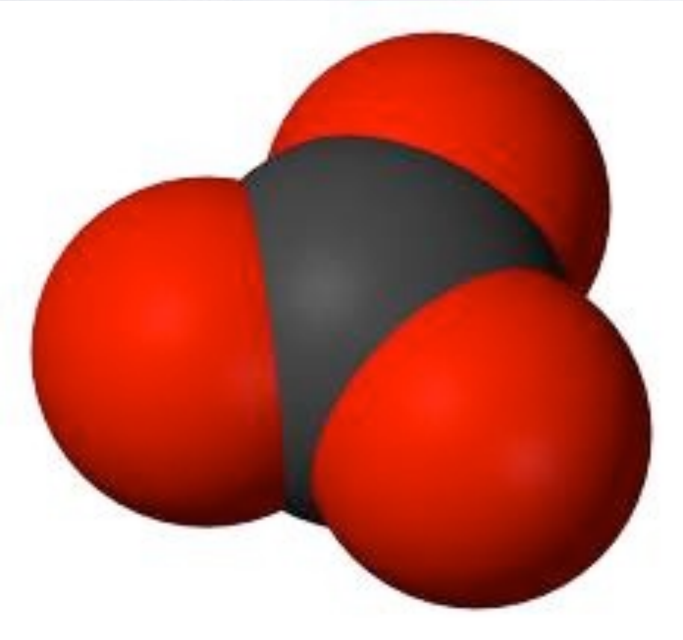
S_2Cl_2 - Disulfur dichloride

POLYATOMIC IONS

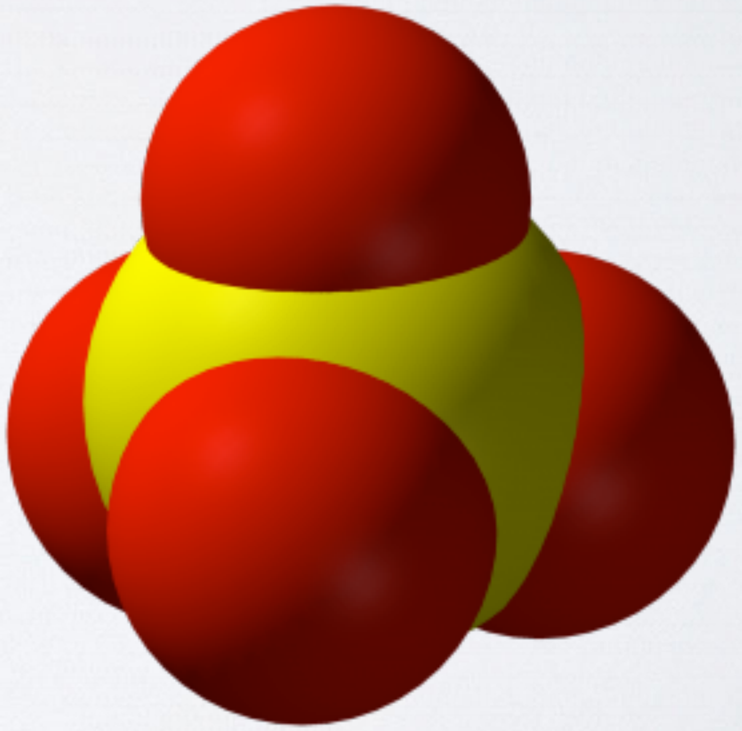
Ions that are comprised of more than one atom;
the atoms remain bound together.

See chem200 website for polyatomic ions you need to know

Carbonate ion: CO_3^{2-}



Sulfate ion: SO_4^{2-}



See sdsuchem200.com for PDF of all Polyatomics Ions - Memorize

POLYATOMIC IONS

Common Polyatomic Ions

Name	Formula	Related Acid	Formula
ammonium	NH_4^+		
hydronium	H_3O^+		
oxide	O^{2-}		
peroxide	O_2^{2-}		
hydroxide	OH^-		
acetate	CH_3COO^-	acetic acid	CH_3COOH
cyanide	CN^-	hydrocyanic acid	HCN
azide	N_3^-	hydrazoic acid	HN_3
carbonate	CO_3^{2-}	carbonic acid	H_2CO_3
bicarbonate	HCO_3^-		
nitrate	NO_3^-	nitric acid	HNO_3
nitrite	NO_2^-	nitrous acid	HNO_2
sulfate	SO_4^{2-}	sulfiric acid	H_2SO_4

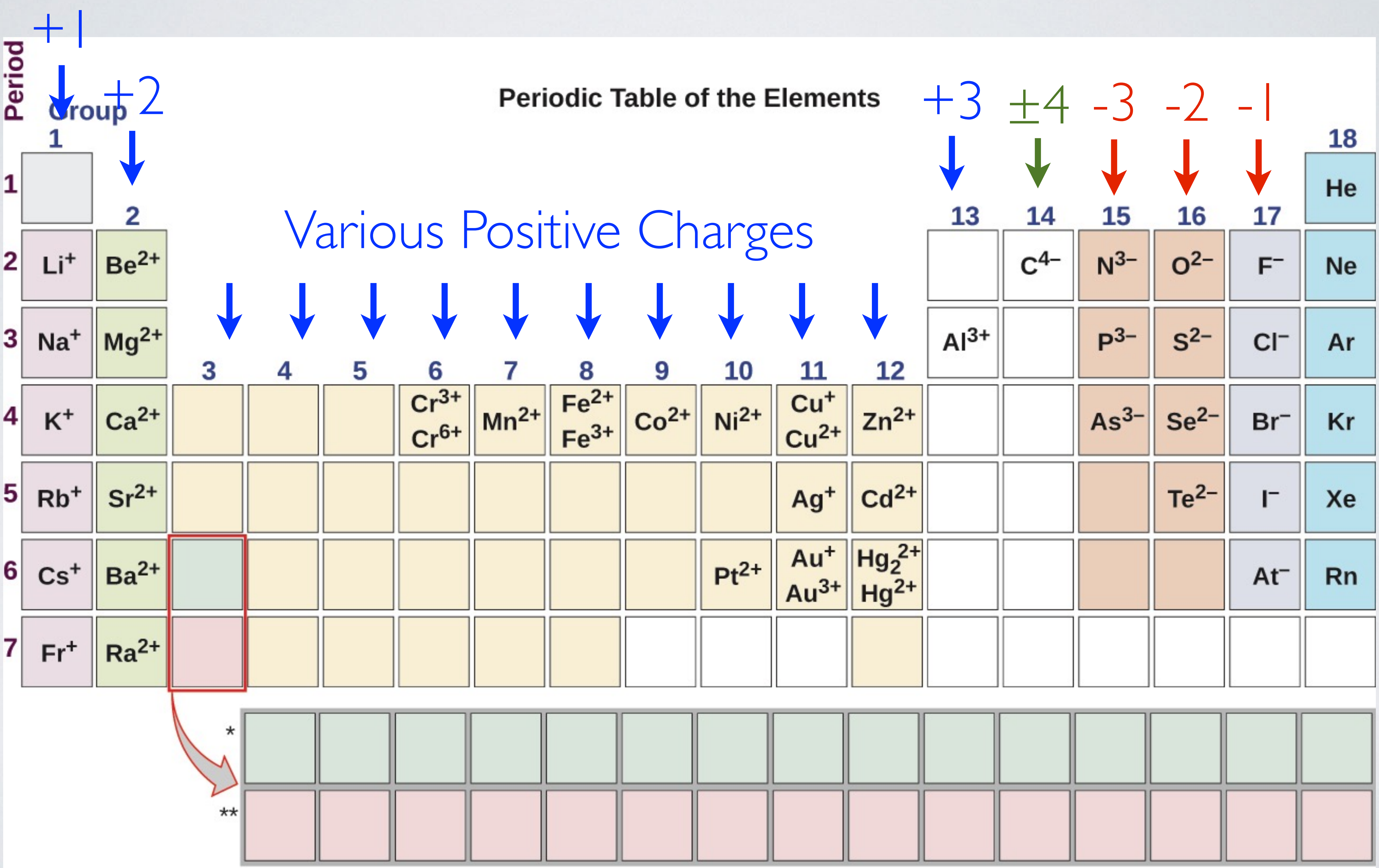
Table 2.5

Common Polyatomic Ions

Name	Formula	Related Acid	Formula
hydrogen sulfate	HSO_4^-		
sulfite	SO_3^{2-}	sulfurous acid	H_2SO_3
hydrogen sulfite	HSO_3^-		
phosphate	PO_4^{3-}	phosphoric acid	H_3PO_4
hydrogen phosphate	HPO_4^{2-}		
dihydrogen phosphate	$H_2PO_4^-$		
perchlorate	ClO_4^-	perchloric acid	$HClO_4$
chlorate	ClO_3^-	chloric acid	$HClO_3$
chlorite	ClO_2^-	chlorous acid	$HClO_2$
hypochlorite	ClO^-	hypochlorous acid	$HClO$
chromate	CrO_4^{2-}	chromic acid	$H_2Cr_2O_4$
dichromate	$Cr_2O_7^{2-}$	dichromic acid	$H_2Cr_2O_7$
permanganate	MnO_4^-	permanganic acid	$HMnO_4$

Table 2.5

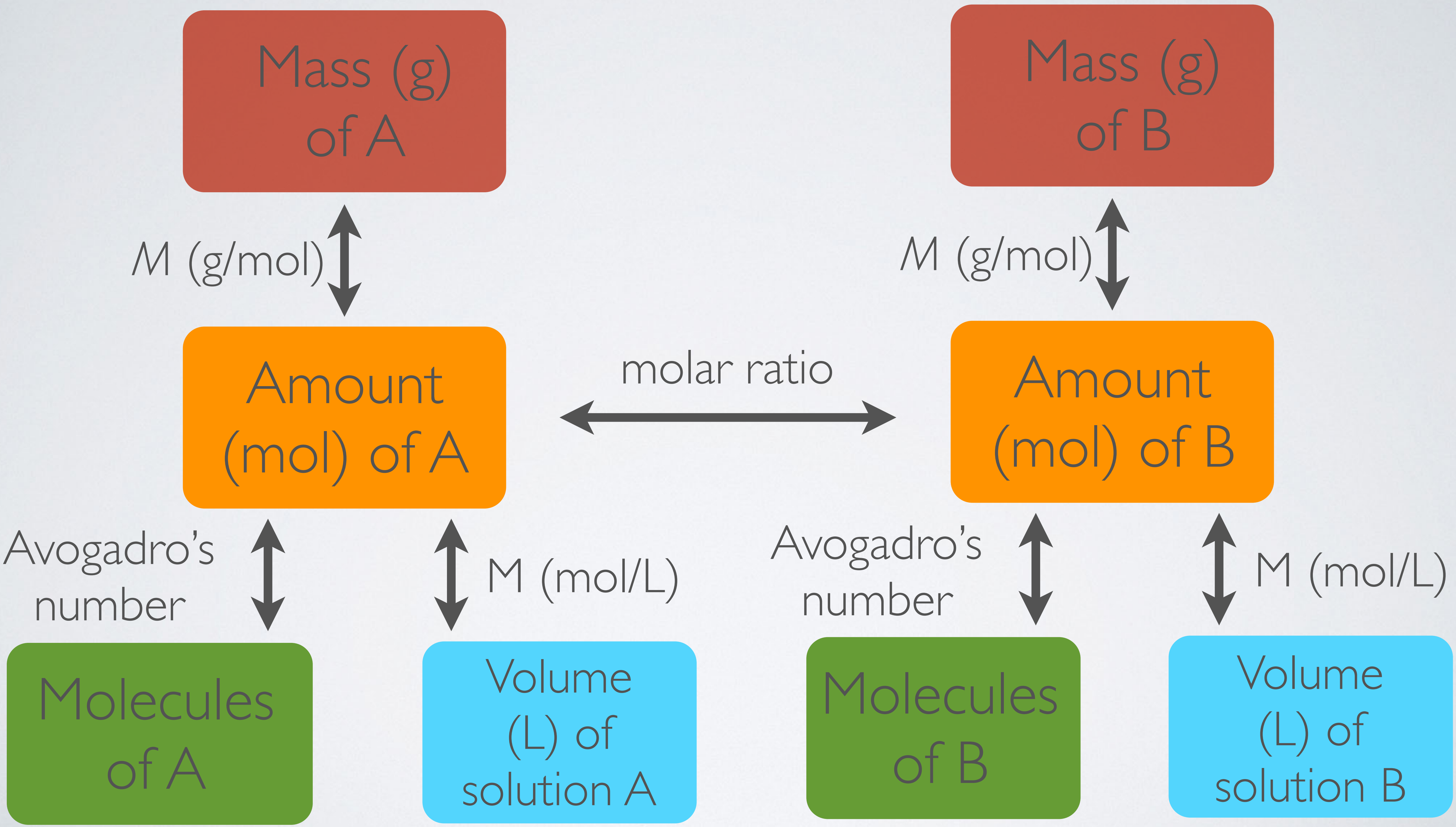
IONIC CHARGES



CHAPTER 3

- Defining the relationship between mass and moles.
- Determining molecular formulas from empirical formulas.
- Calculate solution concentrations using molarity.
- Perform dilution calculations.
- Calculate solution concentrations using molarity.
- Perform dilution calculations.
- Express and calculate concentrations in a variety of units (e.g. w/w%, v/v%, ppm, ppb).

MASS-MOLE-NUMBER RELATIONSHIPS



DILUTIONS CALCULATIONS

- Solutions often need to be **diluted** to obtain the **desired concentration**, from a higher concentration stock solution.

- Calculations for dilutions require us to determine the total **number of moles** involved in the dilution.

- M_1V_1 = # of moles = M_2V_2

PERCENTAGES

- The expression of concentration as a percentage is very similar to how percentage grades are expressed.

- The key is to use the proper units for each calculation.

Mass percent (w/w%)

$$mass\ \ percent\ = \frac{mass\ \ of\ \ solute}{mass\ \ of\ \ solution} \times 100\%$$

Volum percent (v/v%)

$$volume\ \ percent\ = \frac{vol.\ \ of\ \ solute}{vol.\ \ of\ \ solution} \times 100\%$$

Mass-volume percent (w/v%)

$$mass\text{-}volume\ \ percent\ = \frac{mass\ \ of\ \ solute}{vol.\ \ of\ \ solution} \times 100\%$$

PARTS PER MILLION

- Concentrations are occasionally expressed in terms of parts per million (ppm) or parts per billion (ppb), typically when the concentrations are very small.

- The calculations are similar to those for w/w% and v/v%.

$$ppm = \frac{mass\ \ of\ \ solute}{mass\ \ of\ \ solution} \times 10^6$$

$$ppb = \frac{mass\ \ of\ \ solute}{mass\ \ of\ \ solution} \times 10^9$$

CHAPTER 4

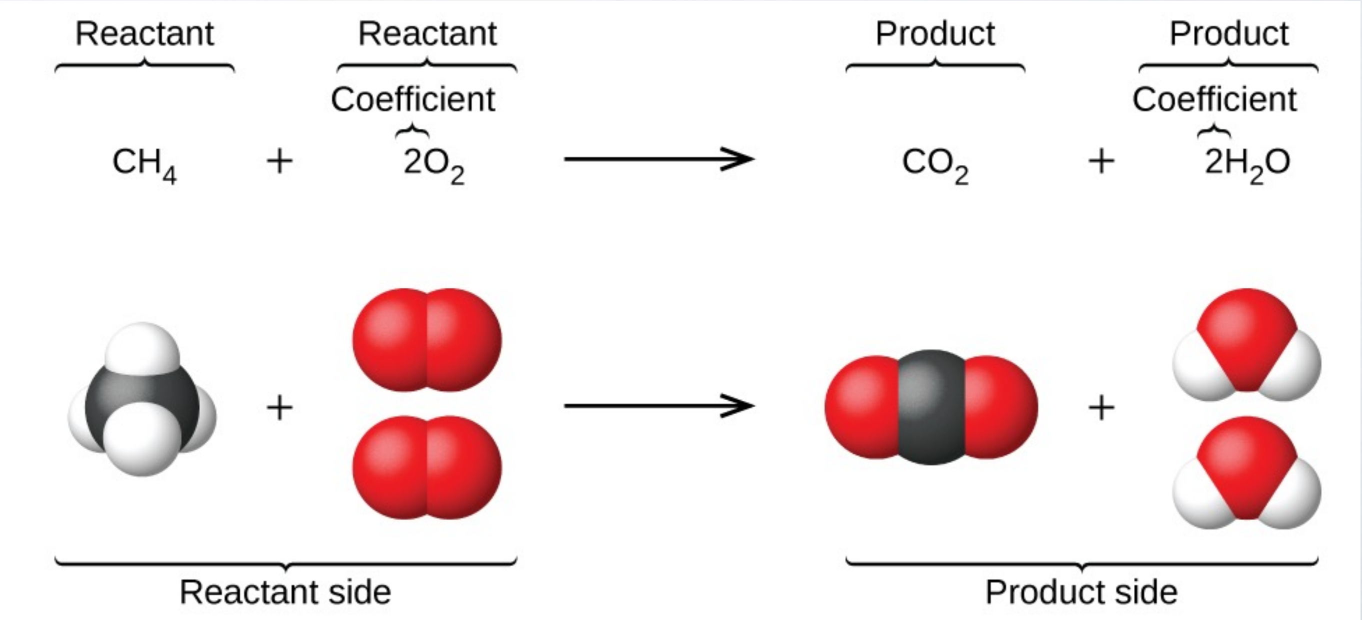
- Balance chemical reactions.
- Express aqueous ionic reactions in various manners.
- Identify spectator ions in aqueous ionic reactions.
- Identify precipitates in aqueous ionic reactions.
- Identify acid-base reactions and their respective products.
- Calculate acid-base neutralization endpoints.
- Determine the oxidation states of elements in compounds.
- Identify the oxidizing and reducing agents in redox reactions.
- Perform stoichiometric calculations involving mass, moles, and solution molarity.
- Calculate theoretical, and percent yields for chemical reactions.

BALANCING CHEMICAL EQUATIONS

- It is crucial to have **properly balanced** reactions when trying to interpret chemical reactions.

- The balanced reaction shows us how much of each **reagent is required** and how much of each **product is formed**.

Methane (CH_4) undergoes a combustion reaction with oxygen (O_2), producing carbon dioxide (CO_2) and water (H_2O).



IONIC REACTIONS

- Many chemical reactions which take place in aqueous solutions involve **ionic compounds**.

- These ionic reactions can be **depicted in various forms** depending on how we wish to focus our attention.

- The various forms include:

  - The **molecular equation:** $Pb(NO_3)_{2(aq)} + 2KI_{(aq)} \rightarrow PbI_{2(s)} + 2KNO_{3(aq)}$

  - The **complete ionic equation:** $Pb^{2+}_{(aq)} + 2NO_3^-{}_{(aq)} + 2K^+_{(aq)} + 2I^-_{(aq)} \rightarrow PbI_{2(s)} + 2K^+_{(aq)} + 2NO_3^-{}_{(aq)}$

  - The **net ionic equation:** $Pb^{2+}_{(aq)} + 2I^-_{(aq)} \rightarrow PbI_{2(s)}$

REACTION CLASSIFICATIONS

- There are three principle aqueous chemical reactions that we will focus on in this course:
  - Precipitations reactions
  - Acid-base reactions
  - Redox reactions (oxidation-reductions)

PRECIPITATION REACTIONS

- Precipitation reactions occur when **pairs of insoluble ions** (e.g. Ag^+ and $Cl^–$) are both present in solution at the same time.

- A mixture of aqueous solutions may result in **more than one precipitate** being formed, if more than one insoluble pair is present.

- Knowledge of the **common soluble and insoluble ions** is required to predict precipitations (solubility rules).

SOLUBILITY RULES

Soluble

1. <u>All common compounds of Group 1A(1) ions</u> (Li^+, Na^+, K^+...) and ammonium ions ($NH4^+$)

2. All common <u>nitrates</u> (NO_3^-), <u>acetates</u> ($CH_3CO_2^-$) and most <u>perchlorates</u> (ClO_4^-)

3. All common <u>chlorides</u> (Cl^-), <u>bromides</u> (Br^-) and <u>iodides</u> (I^-); *except* those of Ag^+, Pb^{2+}, Cu^+ and Hg_2^{2+}. All common <u>fluorides</u> (F^-) are soluble; *except* for Pb^{2+} & Group2A(2)

4. All common <u>sulfates</u> (SO_4^{2-}); *except* Ca^{2+}, Sr^{2+}, Ba^{2+}, Ag^+ & Pb^{2+}

SOLUBILITY RULES

Insoluble

1) All common metal hydroxides are **insoluble**; *except* those of Group 1A(1) and the larger members of Group 2A(2) - beginning with Ca^{2+}.

2) All common carbonates (CO_3^{2-}) and phosphates (PO_4^{3-}) are **insoluble**; *except* those from Group 1A(1) and ammonium (NH_4^+).

3) All common sulfides (S^{2-}) are **insoluble**; *except* those of Groups 1A(1), 2(A)2 and NH_4^+.

SELECTED ACIDS & BASES

Strong Acids

Hydrochloric acid, **HCl**
Hydrobromic acid, **HBr**
Hydroiodic acid, **HI**
Nitric acid, **HNO_3**
Sulfuric acid, **H_2SO_4**
Perchloric acid, **$HClO_4$**

Strong Bases

Sodium hydroxide, **$NaOH$**
Potassium hydroxide, **KOH**
Calcium hydroxide, **$Ca(OH)_2$**
Strontium hydroxide, **$Sr(OH)_2$**
Barium hydroxide, **$Ba(OH)_2$**

Weak Acids

Hydrofluoric acid, **HF**
Phosphoric acid, **H_3PO_4**
Acetic acid, **CH_3COOH**
(or **$HC_2H_3O_2$**)

Weak Bases

Ammonia, **NH_3**

ACID-BASE NEUTRALIZATION

Acid + Base → Water + Salt

<u>Molecular equation</u>

$$HCl_{(aq)} + NaOH_{(aq)} \rightarrow H_2O_{(l)} + NaCl_{(aq)}$$

<u>Total ionic equation</u>

$$H^+_{(aq)} + \cancel{Cl^-}_{(aq)} + \cancel{Na^+}_{(aq)} + OH^-_{(aq)} \rightarrow H_2O_{(l)} + \cancel{Na^+}_{(aq)} + \cancel{Cl^-}_{(aq)}$$

<u>Net ionic equation</u>

$$H^+_{(aq)} + OH^-_{(aq)} \rightarrow H_2O_{(l)}$$

Hint: Balance the H^+ with OH^- the rest will work itself out.

OXIDATION NUMBER RULES

General Rules

1. For an atom in its elemental form (e.g. Na, O_2, Cl_2,...) the O.N. = 0.
2. For a monoatomic ion (e.g. Br^-, Cu^{2+},...) the O.N. = ion charge.
3. The sum of the O.N. values for atoms in a compound equals zero. For polyatomic ions the sum equals the charge of the ion.

Specific Rules

1. For Group 1(A)1 - O.N. is +1 in all compounds
2. For Group 2(A)2 - O.N. is +2 in all compounds
3. For hydrogen - O.N. is +1 when bound to nonmetals
4. For fluorine - O.N. is -1 when bound to metals & boron
5. For oxygen - O.N. is -1 when in peroxides (e.g. H_2O_2)
   - O.N. is -2 for all others (except with fluorine)
6. For Group 7(A)17 - O.N. is -1 when with metals, nonmetals (except O) & for other halogens lower in group

REDOX TERMINOLOGY

$$2Mg_{(s)} + O_{2(g)} \rightarrow 2MgO_{(s)}$$

$$2Mg \rightarrow 2Mg^{2+} + 4e^-$$

O.N.: 0 +2

- Mg loses electrons
- Mg is oxidized
- Mg is the reducing agent
- The oxidation number of Mg is increased

$$O_2 + 4e^- \rightarrow 2O^{2-}$$

O.N.: 0 -2

- O gains electrons
- O is reduced
- O is the oxidizing agent
- The oxidation number of O is decreased

TYPES OF REDOX REACTIONS

- The different types of redox reactions are classified by the components of the reaction and what happens to those components.

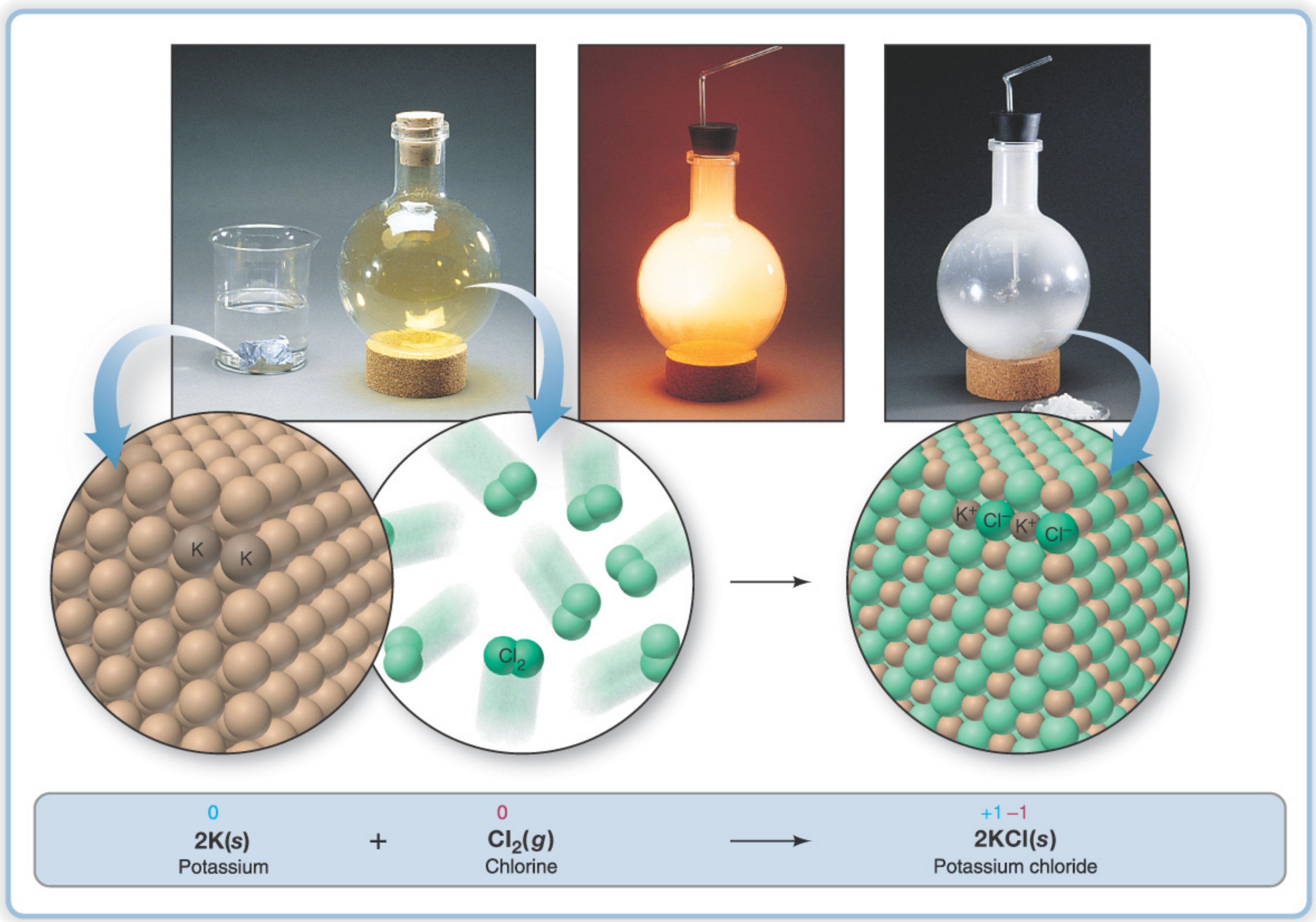
- There are four types of redox reactions which involve elements - **combination, decomposition, displacement and combustion.**

- In these reactions, elements may be reagents, products or transferred during the reaction.

COMBINATION REACTION

$$2K_{(s)} + Cl_{2(g)} \rightarrow 2KCl_{(s)}$$

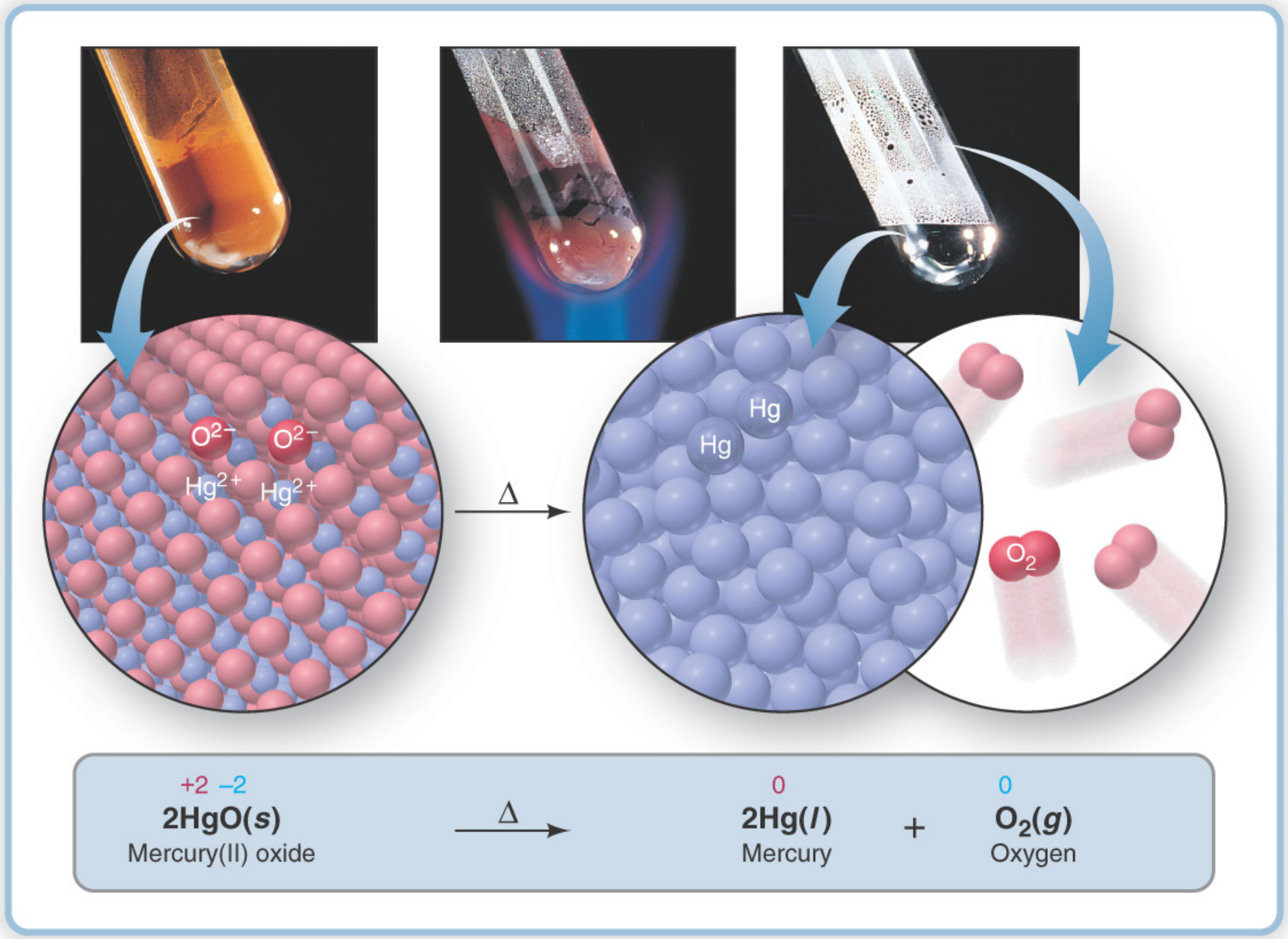
$$2NO_{(g)} + O_{2(g)} \rightarrow 2NO_{2(g)}$$



DECOMPOSITION REACTION

$$2HgO_{(s)} \xrightarrow{\Delta} 2Hg_{(l)} + O_{2(g)} \qquad \Delta = \text{heat}$$

$$2H_2O_{(l)} \xrightarrow{\text{electricity}} 2H_{2(g)} + O_{2(g)}$$

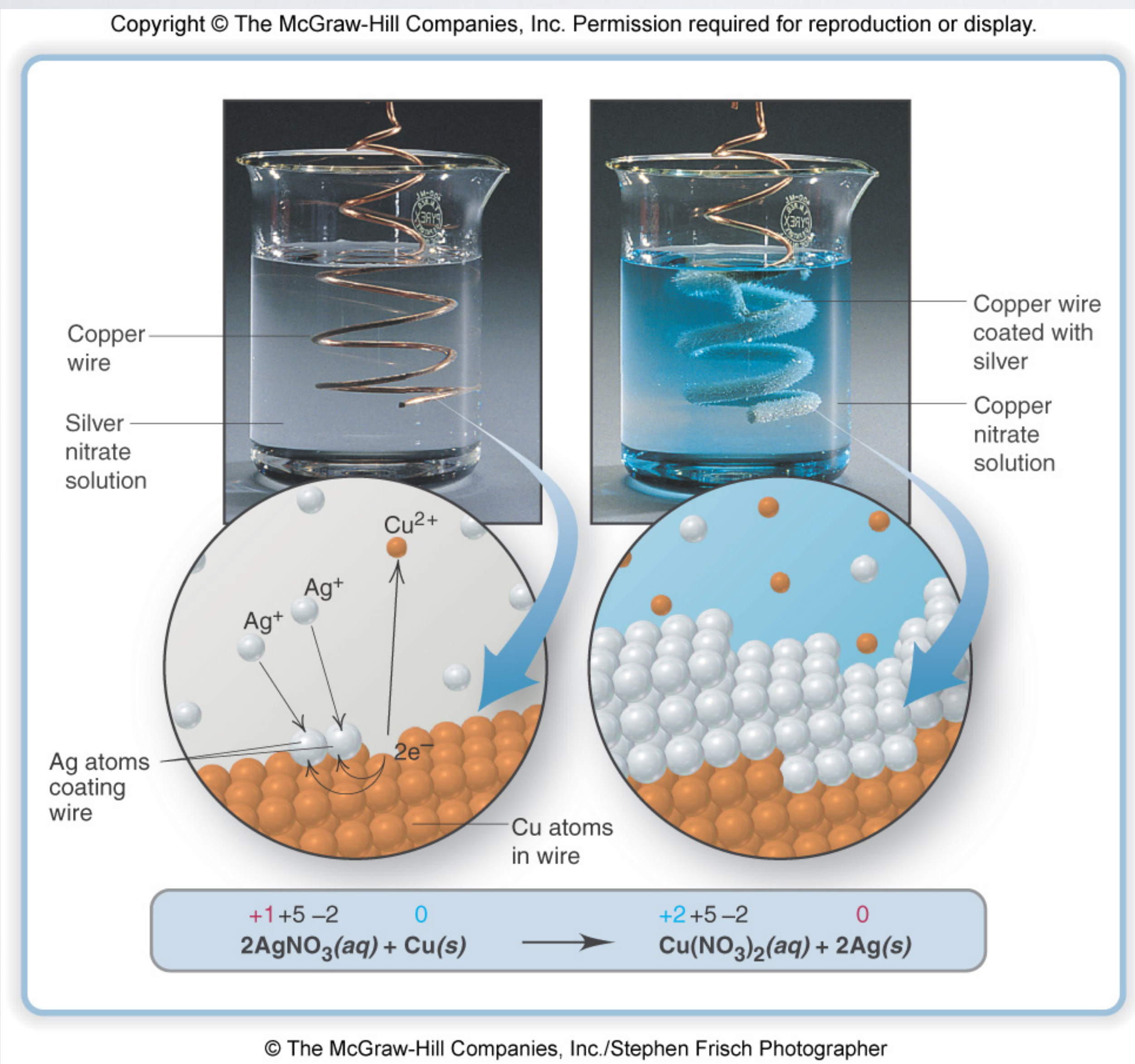


DISPLACEMENT REACTIONS

Displacing one metal by another metal

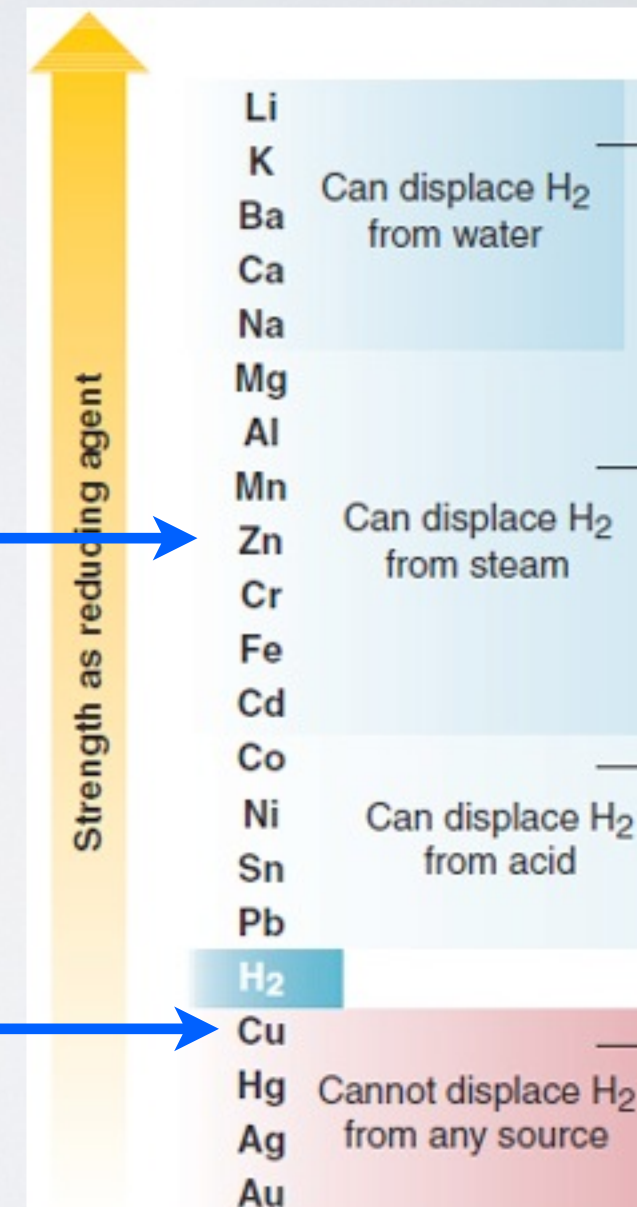
$$Cu_{(s)} + 2AgNO_{3(aq)} \rightarrow Cu(NO_3)_{2(aq)} + 2Ag_{(s)}$$

$$Zn_{(s)} + CuSO_{4(aq)} \rightarrow ZnSO_{4(aq)} + Cu_{(s)}$$



More reactive

Less reactive



COMBUSTION REACTIONS

- Combustion reactions always involve oxygen.
- The reactions reduce oxygen and release energy, frequently as heat and light.

$$2CO_{(g)} + O_{2(g)} \rightarrow 2CO_{2(g)}$$

$$2C_4H_{10(g)} + 13O_{2(g)} \rightarrow 8CO_{2(g)} + 10H_2O_{(g)}$$

$$C_6H_{12}O_{6(g)} + 6O_{2(g)} \rightarrow 6CO_{2(g)} + 6H_2O_{(g)}$$

REACTION YIELDS

- The **reaction yield** is a measure of the completeness of a reaction; quantifying how much of the possible product was formed.

- Determining the **theoretical yield** for a reaction requires a **balanced chemical reaction**, and the identification of the **limiting reagent**.

- The limiting reagent is the reagent that will be entirely c**onsumed first**, stoping the reaction (limiting the amount of product formed).

LIMITING REAGENT

- The Haber-Bosch process produces ammonia from nitrogen and hydrogen gas (unbalanced reaction below).

  - $\_N_{2(g)} + \_H_{2(g)} \rightarrow \_NH_{3(g)}$

- <u>Hydrogen limiting reagent</u>: How many grams of ammonia would be produced if 4.04 g of H_2 and an infinite amount of N_2? How much N_2 is consumed?

REACTION YIELDS

- Not every reaction proceeds perfectly to produce 100% of the maximum product.
- Reactions that are imperfect have **reaction yields** of less than 100%.
- Considering the reaction: $\_N_{2(g)} + \_H_{2(g)} \rightarrow \_NH_{3(g)}$
- The reaction was performed with 4.04 g of H_2 and excess N_2. At the end of the reaction your yield is only 15.0%. What mass of NH_3 is formed?
- If the reaction produced 7.24 g NH_3. What would the yield be?

LIMITING REAGENT PROBLEM

- What is the limiting reagent when 2.00 g of Si and 1.50 g of N_2 is reacted? How many moles of Si_3N_4 will be produced? Be sure to balance the equation first.

$$\_Si_{(s)} + \_N_{2(g)} \rightarrow \_Si_3N_{4(s)}$$