CHEM 200/202

Professor Theresa Carlson
Office: GMCS-213B

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

My office hours will be held on zoom via MSLC on **Mondays & Wednesday from 8:00 am to 10:00 am** or by appointment

IMPORTANT ANNOUNCEMENTS

1. Email chem200@sdsu.edu ONLY unless its regarding lab or discussion which then you need to email your respective TA.

2. Follow the directions in adding OWL that Theresa provided you in Module 1.0 > Adding OWL (READ). She made a video and has a pdf file with directions.

3. **There is no course key for OWL.**

4. **Read the announcements and emails that Theresa, Megan, or your TAs sends out.**

5. Again read the syllabus. A lot of questions are being asked that are in the syllabus. For example, emailing when the lab will be and what will take place can be answered by the syllabus. In the syllabus there is a lab schedule, read, use it, and print it out.

6. And for good measure read the announcements before sending out emails. The majority (98%) of questions can be answered by: the syllabus, videos Theresa has made, and in the announcements.

UPCOMING IMPORTANT DATES

- Pre-Assignment: Solubility Experiment **Sunday, February 12th at 11:59 pm**

- Achieve Extra Credit: Laboratory Skills **Sunday, February 12th at 11:59 pm**

- Solubility Experiment Prelab due **Sunday, February 12th at 11:59 pm**

- Volumetric Lab Report due **Sunday, February 12th at 11:59 pm**

- Chapter 1-4 Chapter Problem Sets in OWL Lecture due **Thursday, February 9th at 11:59 pm** (**Start Now)**

- Chapter 1-4 Chapter Assessments in OWL Lecture is **Thursday, February 9th at 11:59 pm** (**Start Now**); 2 chances, no time limit

- Exam 1 starts at **3 pm Friday, February 10th and will close on Saturday, February 11th at 3pm** in OWL Lecture; Chapters 1-4. You have 24hrs. *Only 2 hrs once you start; be sure to give yourself a full 2 hr time slot.*

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.

THE MATH AND SCIENCE LEARNING CENTER (MSLC)

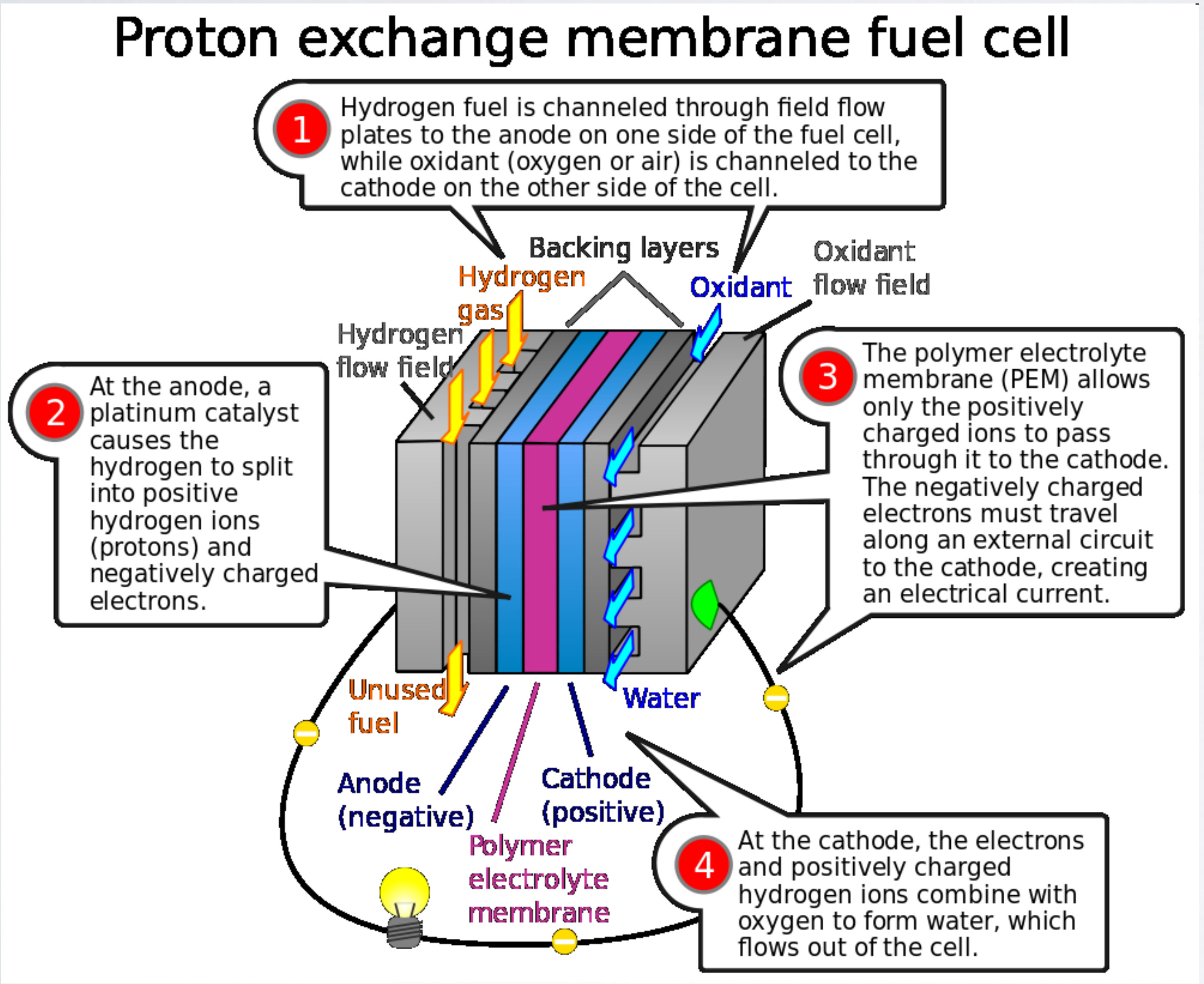
Students are encouraged to make use of The Mathematics and Statistics Learning Center (MSLC) for free STEM tutoring, located in the Love Library, Room 328. For a full list of courses tutored, please visit the MSLC website: https://mlc.sdsu.edu/ .

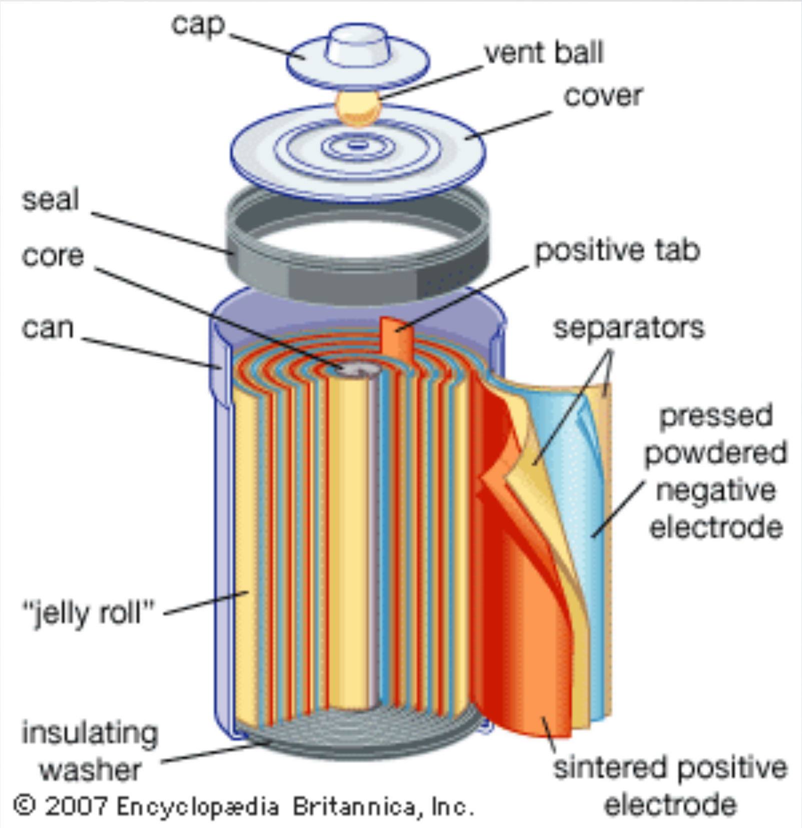
The MSLC is supported by your student success fee. We strongly encourage you to use this wonderful, free resource. Some students believe that they shouldn't need to ask for help, but research has shown that the average grade for students who attend the MLC is almost one full grade higher than those who don't seek such support.

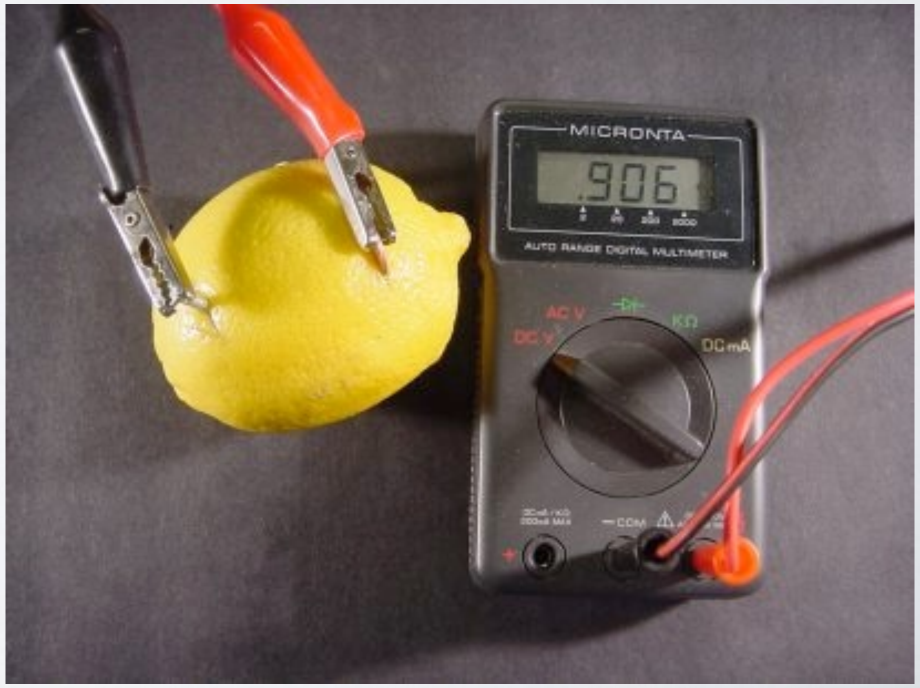
LECTURE OBJECTIVES

- Chapter 4.2-4.4
  - 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.

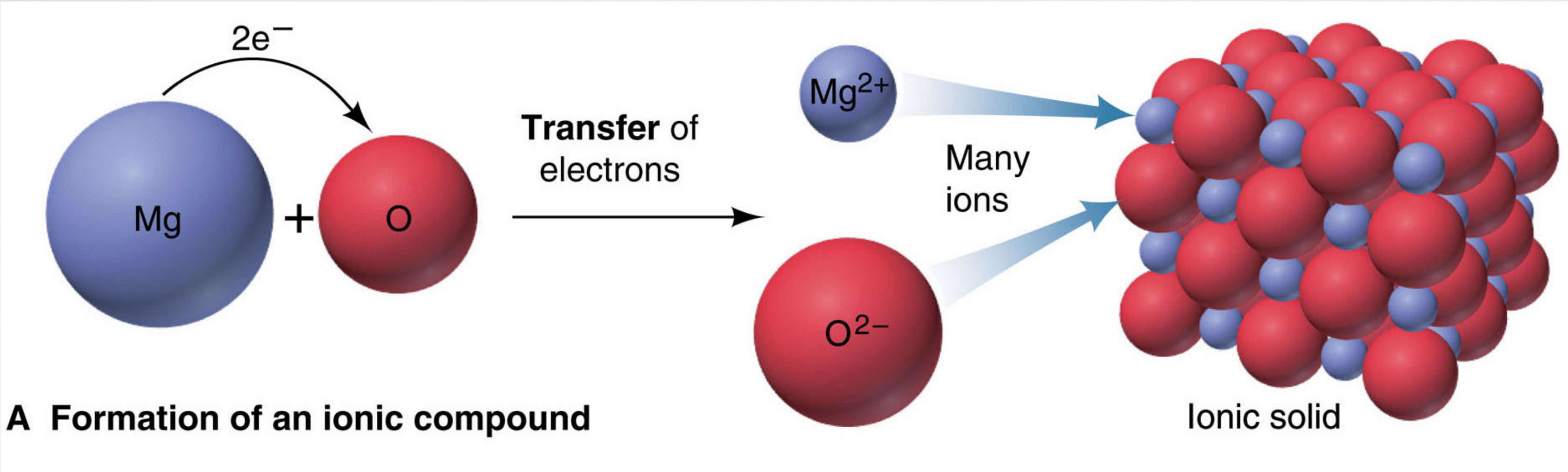
REDOX REACTIONS



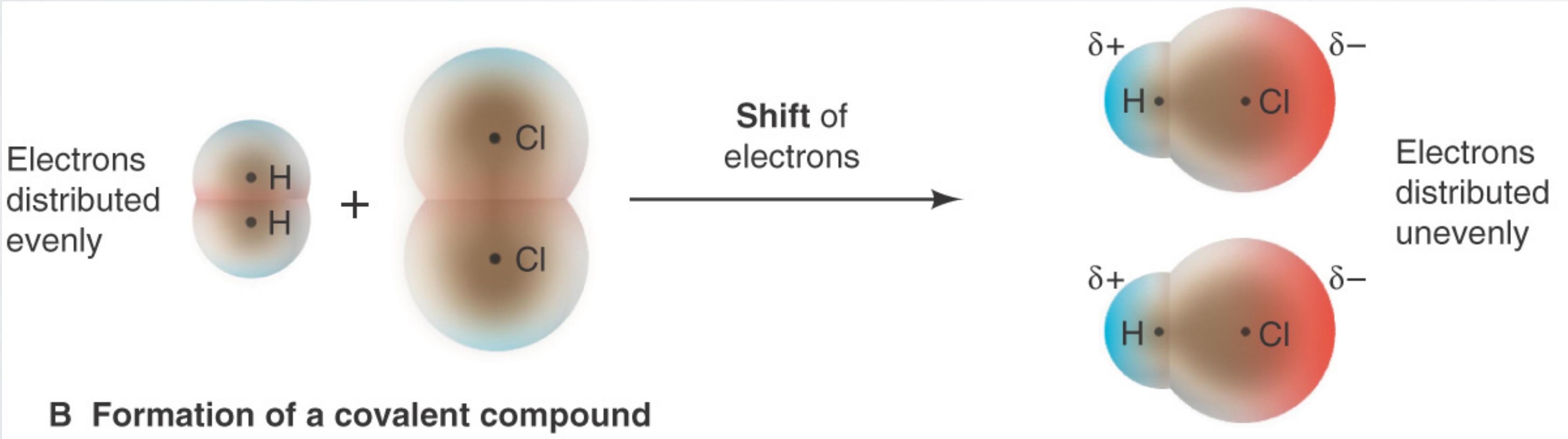




REDOX REACTION IN COMPOUND FORMATION



Electrons are transferred in the formation of ionic compounds.



Electrons are shifted in the formation of covalent compounds.

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.

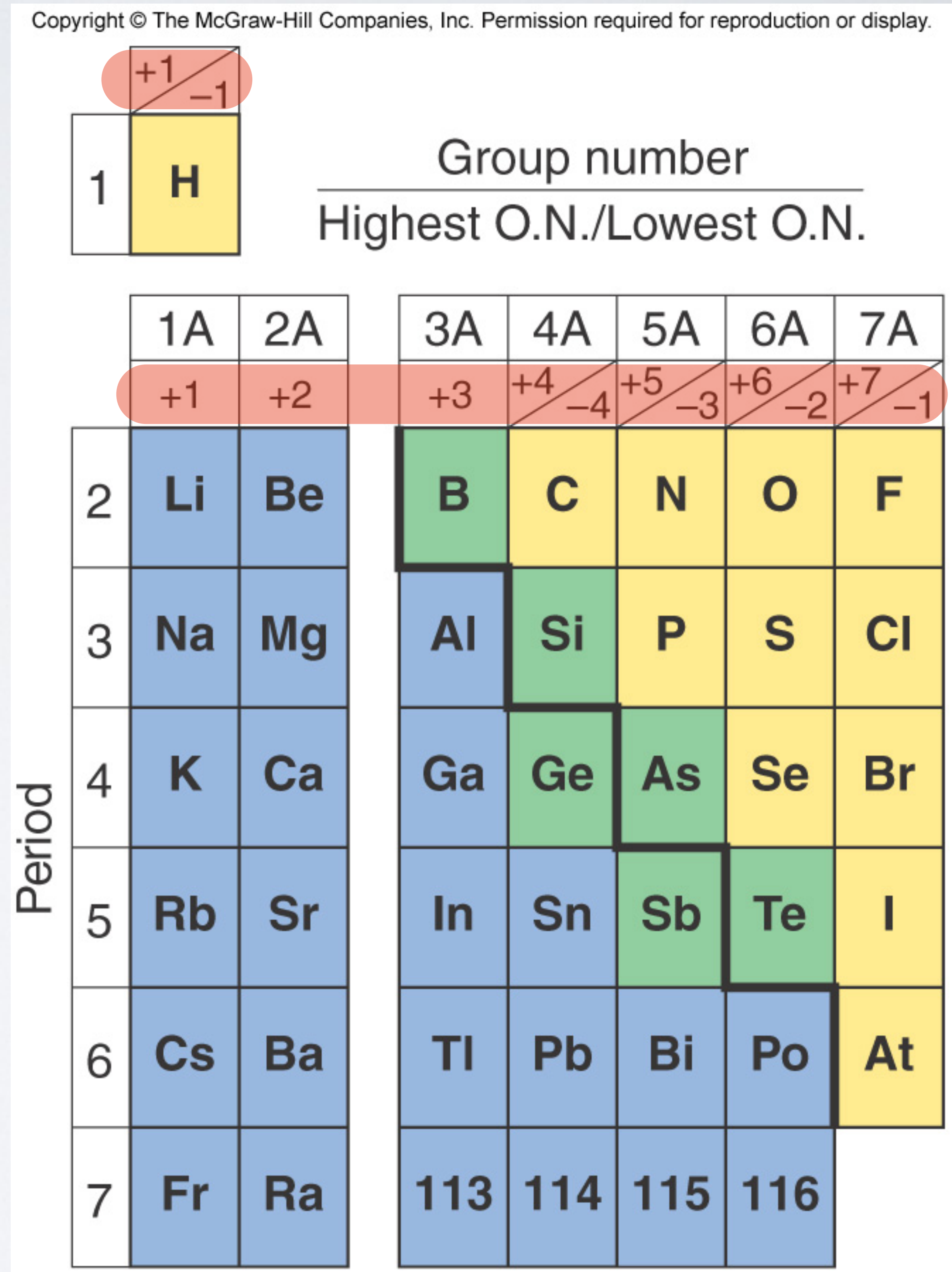
Specific Rules

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

OXIDATION NUMBERS

The main group elements can have different oxidation numbers depending on the molecule they are part of.

Compound	O.N. of nitrogen
NH_3	-3
N_2H_4	-2
NH_2OH	-1
N_2	0
N_2O	+1
NO	+2
NO_2^-	+3
NO_2	+4
NO_3^-	+5



ASSIGNING OXIDATION NUMBERS

(a) H_2S
(b) SO_3^{2-}
(c) Na_2SO_4
(d) KNO_3
(e) AlH_3
(f) NH_4^+
(g) $H_2PO_4^-$

REDOX TERMINOLOGY

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

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

O.N.: 0 +2

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

O.N.: 0 -2

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

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

OXIDATION REDUCTION

OIL RIG

Oxidation
is
loss of electrons

Reduction
is
gain of electrons

LEO GER

Lose
electrons is
oxidation

Gain
electrons is
reduction

QUESTION

Identify the oxidizing agent and reducing agent in the following reaction:

$$Sn_{(s)} + 2H^{+}_{(aq)} \rightarrow Sn^{2+}_{(aq)} + H_{2(g)}$$

Oxidizing agent	Reducing agent	Answer
H^+	Sn	A
H^+	Sn^{2+}	B
Sn	H^+	C
Sn	H_2	D
Sn^{2+}	H_2	E

$Zn + NiO_2 + 4\ H^+ \longrightarrow Ni^{2+} + Zn^{2+} + 2\ H_2O$

In the above redox reaction, use oxidation numbers to identify the element oxidized, the element reduced, the oxidizing agent and the reducing agent.

name of the element oxidized: Zinc

name of the element reduced: Nickel

formula of the oxidizing agent: NiO2

formula of the reducing agent: Zn

TYPES OF REDOX REACTIONS

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

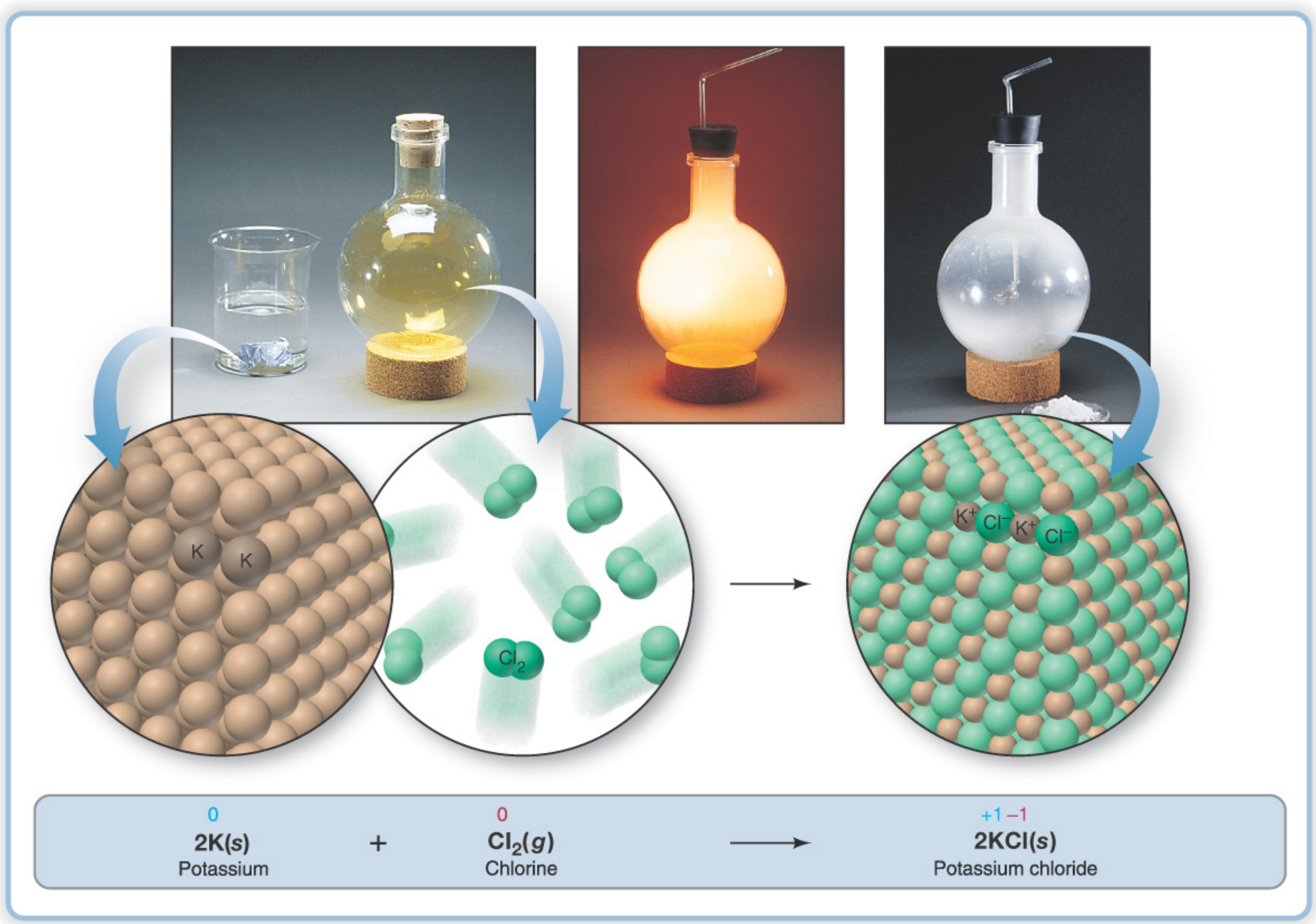
- There are four types of redox reactions which involve elements - combination, decomposition, displacement and combustion.

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

COMBINATION REACTION

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

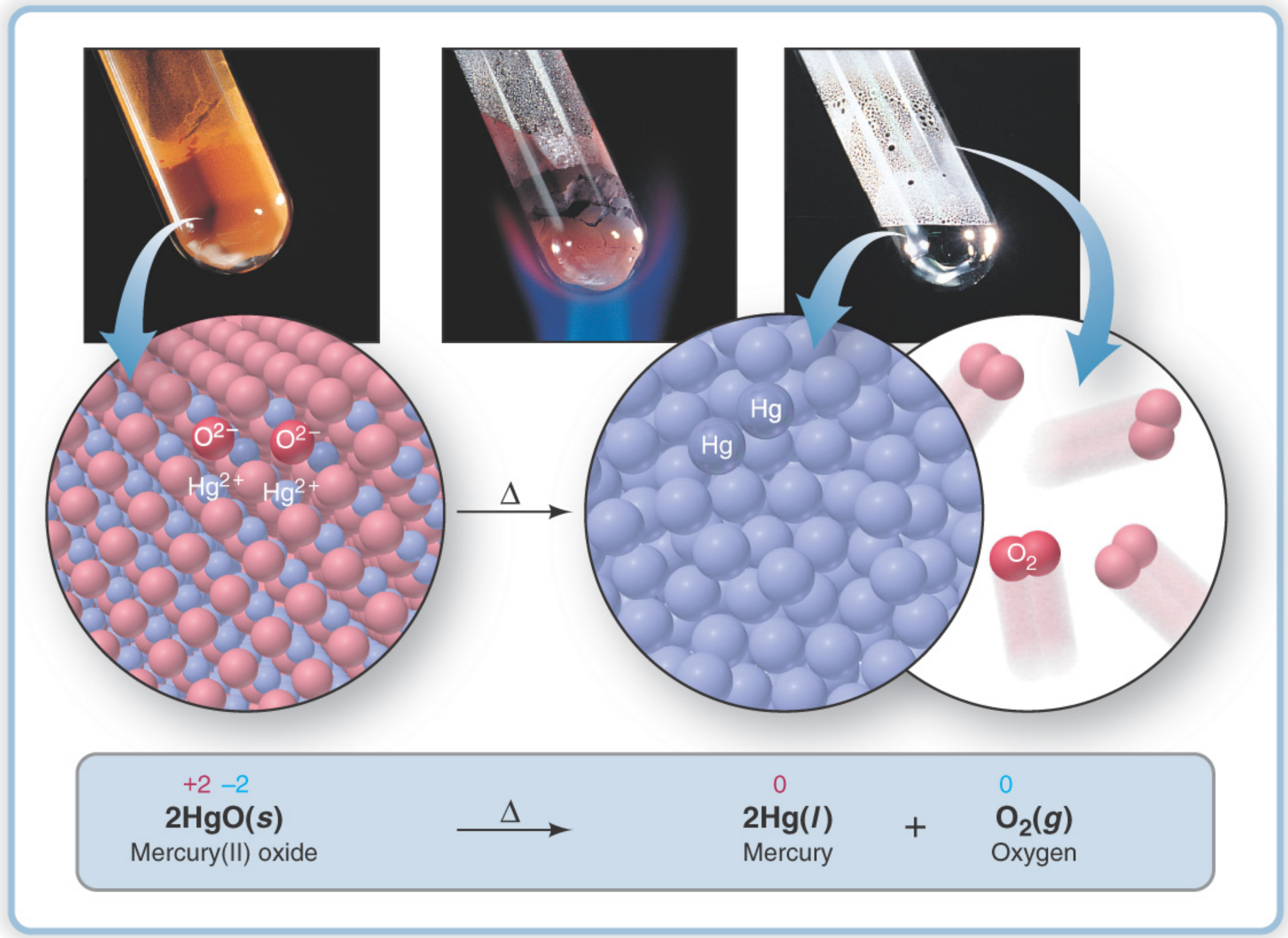
$$2NO_{(g)} + O_{2(g)} \rightarrow 2NO_{2(g)}$$



DECOMPOSITION REACTION

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

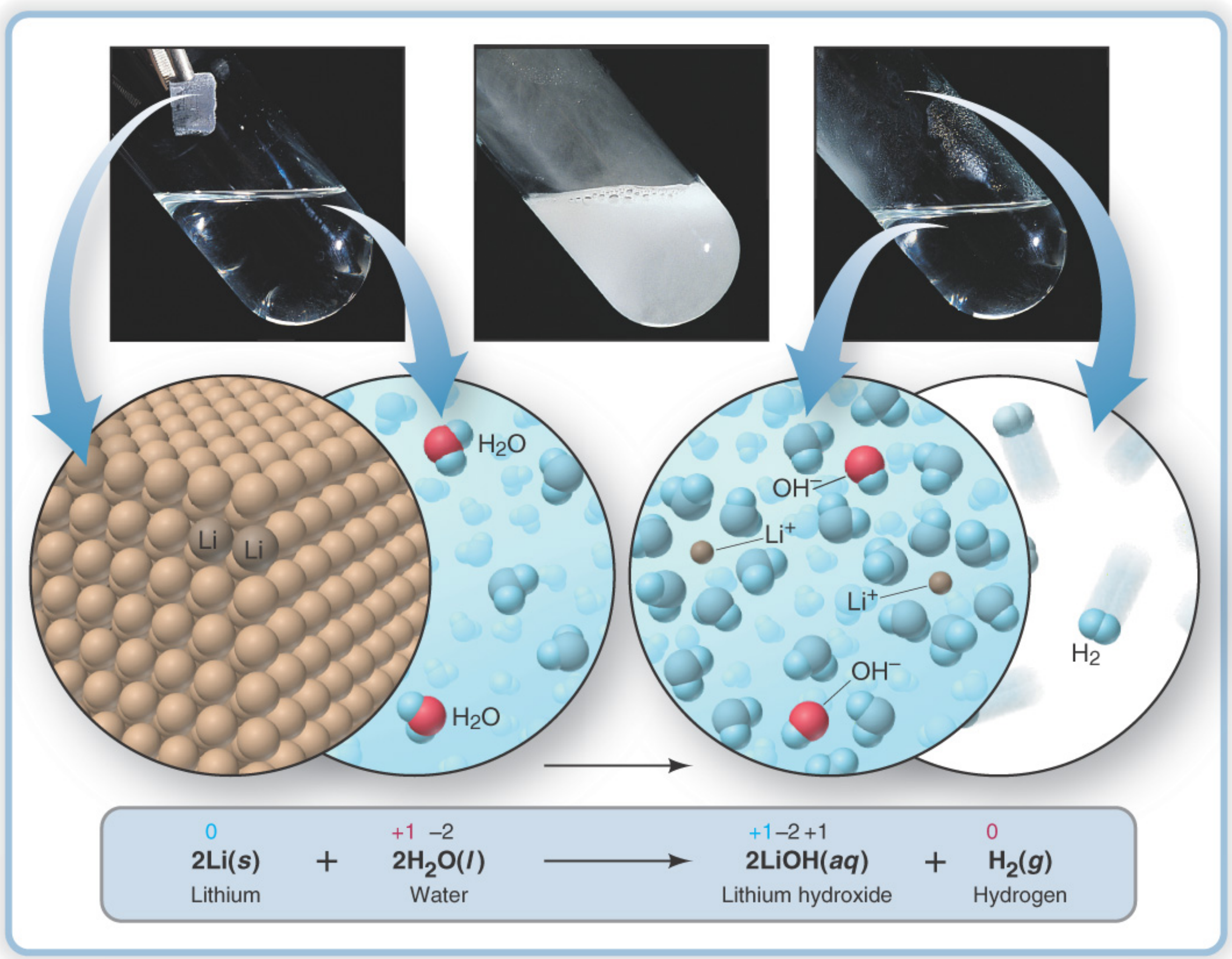
$$2H_2O_{(l)} \xrightarrow{\text{electricity}} 2H_{2(g)} + O_{2(g)}$$



DISPLACEMENT REACTION

An active metal displacing hydrogen from water

$$2Li_{(s)} + 2H_2O_{(l)} \rightarrow 2LiOH_{(aq)} + H_{2(g)}$$

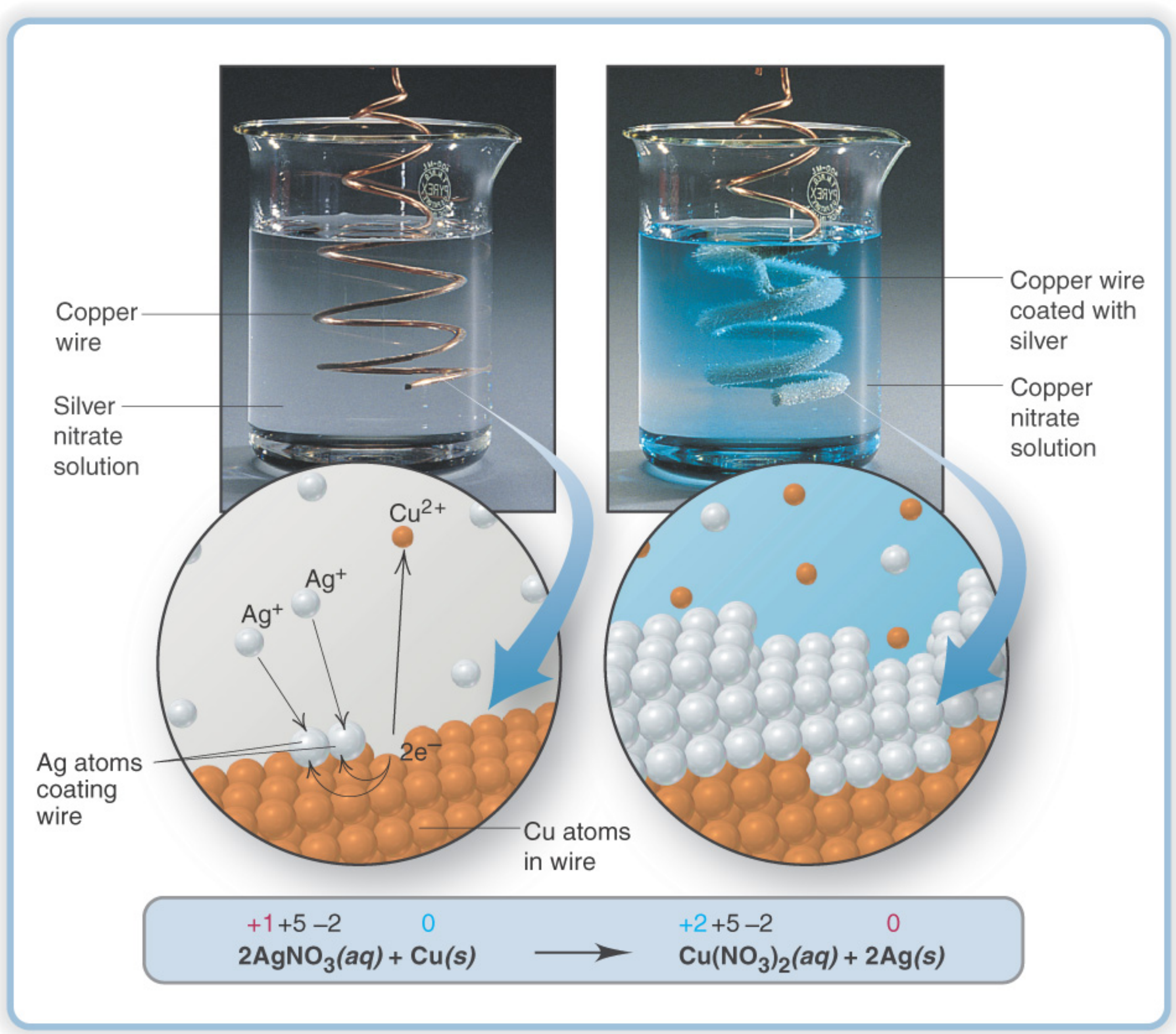


DISPLACEMENT REACTIONS

Displacing one metal by another metal

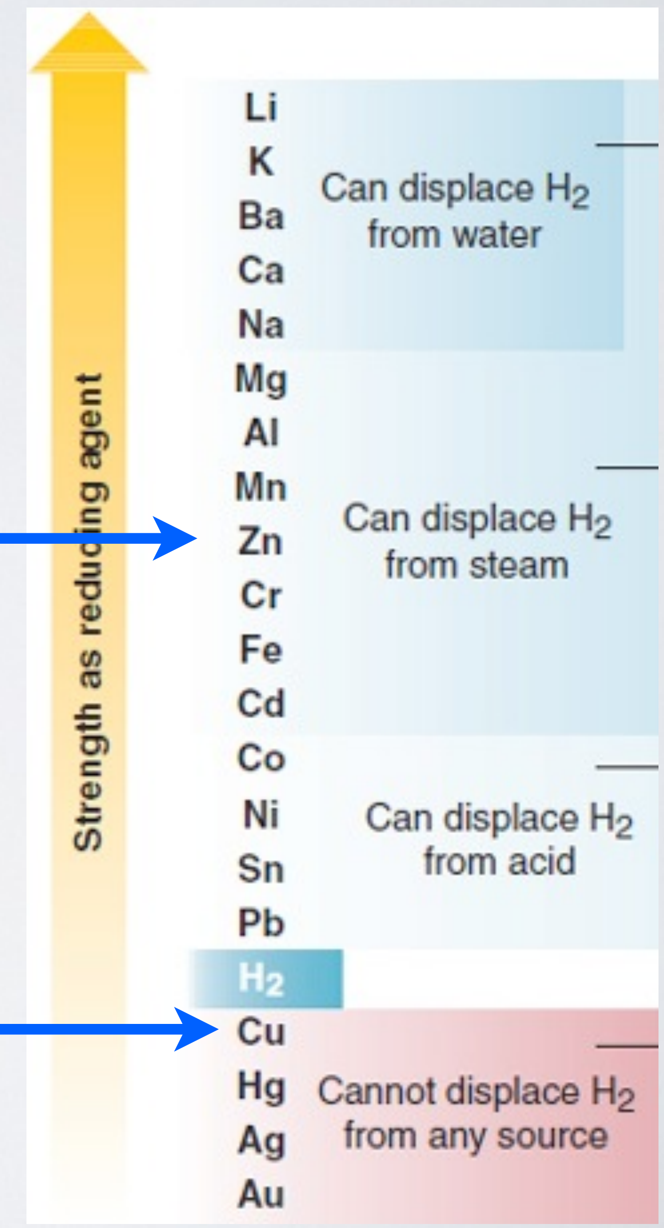
$$Cu_{(s)} + 2AgNO_{3(aq)} \rightarrow Cu(NO_3)_{2(aq)} + 2Ag_{(s)}$$

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



More reactive

Less reactive



COMBUSTION REACTIONS

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

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

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

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

CALCULATING THE QUANTITIES OF REACTANT AND PRODUCTS

A balanced equation is **essential** for all calculations involving chemical change: if you know the number of moles of one substance, the balanced equation tells you the number of moles of the others.

From a balanced equation we can find the stoichiometrically equivalent molar ratios

Example: C_3H_8 (g) +5O_2 (g)   3CO_2 (g) + 4H_2O (g)

1 mol of C_3H_8 reacts (stoichiometrically equivalent) with 5 mol of O_2

1 mol of C_3H_8 produces (stoichiometrically equivalent) with 3 mol of CO_2

1 mol of C_3H_8 produces (stoichiometrically equivalent) with 4 mol of H_2O

3 mol of CO_2 is stoichiometrically equivalent to 4 mol of H_2O

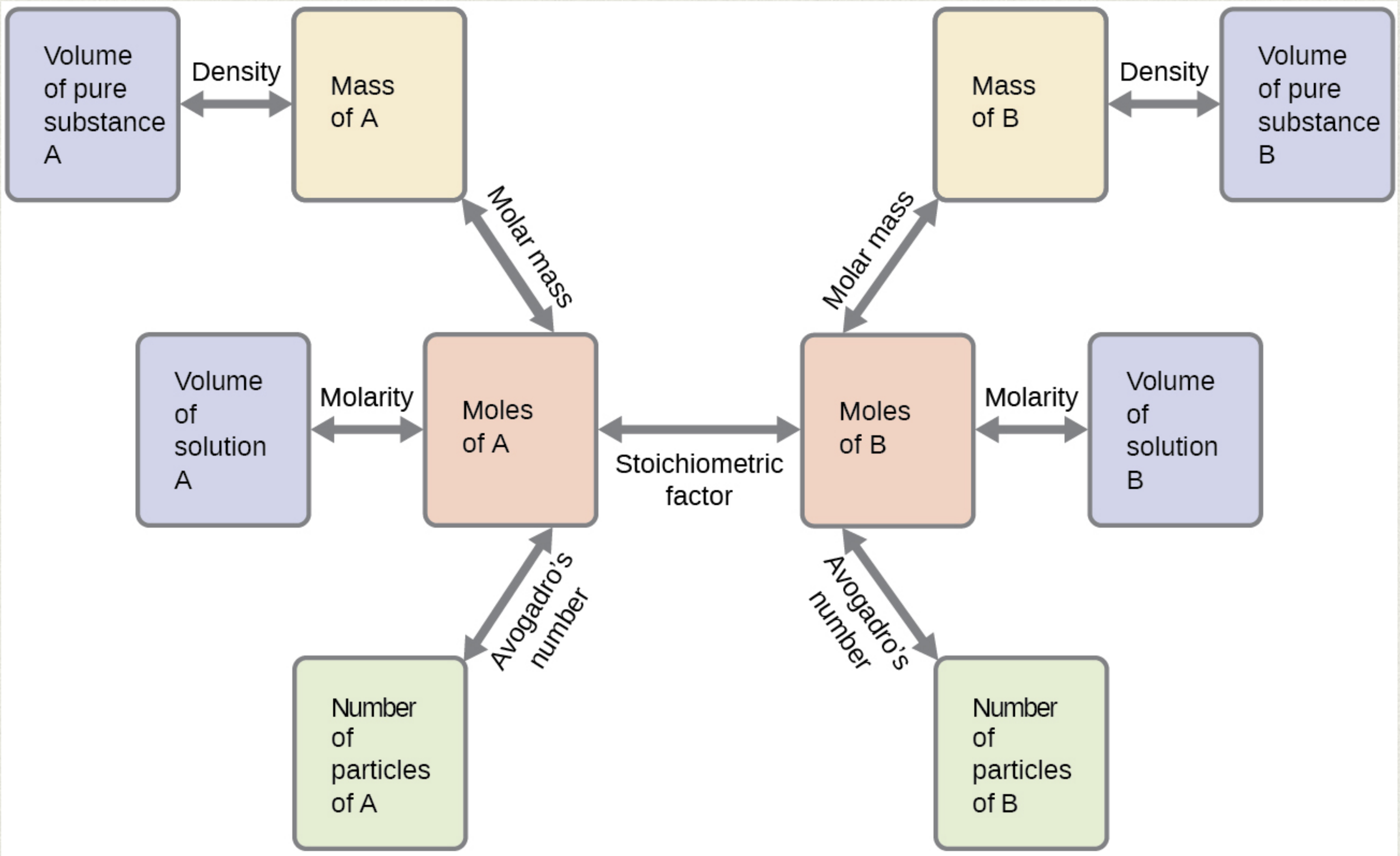
5 mol of O_2 is stoichiometrically equivalent to 3 mol of CO_2

SOLVING STOICHOMETRY PROBLEMS:

1. Write the balanced equation
2. When necessary, convert the mass (or number of entities) of one substance to amount (mol) using its molar mass (or Avogadro's number)
3. Use the mole ratio to calculate the unknown amount (mol) of the other substance.
4. When necessary, convert the amount (mol) of that substance to the desired mass (or number of entities) using its molar mass (or Avogadro's number)

REACTION STOICHIOMETRY

We can now use the balanced chemical equation to derive stoichiometric factors relating to amounts of reactants and products.



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 REACTANT

Limiting Reactant is the reactant that is consumed when a reaction occurs and, therefore, the one that determines the maximum amount of product that can form.

Determining the limiting reactant:

1. Use the balance equation to see how much product is forms from the given amount of each reactant.

2. The limiting reactant is the one that yields the **least** amount of product and the excess reactant is the one that yields the **more** amount of product.

Sample Problem 3.19: In a preparation of ClF_3, 0.750 mol of Cl_2 reacts with 3.00 F_2. Find the limiting reactant.

1. Create a balanced equation

$$Cl_2\ (g) + 3F_2\ (g) \longrightarrow 2ClF_3\ (g)$$

2. For each reactant find the moles of the product ClF_3

$$0.750 \text{ mol } Cl_2 \times (2 \text{ mol } ClF_3 / 1 \text{ mol } Cl_2) = \boxed{1.50 \text{ mol of } ClF_3}$$

$$3.00 \text{ mol } F_2 \times (2 \text{ mol } ClF_3 / 3 \text{ mol } F_2) = 2.00 \text{ mol of } ClF_3$$

Cl_2 is the limiting reagent; while F_2 is the excess reagent

LIMITING REAGENT

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

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

- Hydrogen limiting reagent: 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?

THEORETICAL, ACTUAL, AND PERCENT YIELDS

- Theoretical yield= the amount of product calculated from the molar ratio in the balanced equation

- Actual yield= the **actual** amount of product actually obtained in an experiment

- Percent yield= the actual yield expressed as a percentage of the theoretical yield

$$Percent\ \ yield = \frac{actual\ \ yield}{theoretical\ \ yield} \times 100$$

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

For the following reaction, **19.1** grams of **sodium chloride** are allowed to react with **58.8** grams of **silver nitrate**.

sodium chloride (aq) + silver nitrate (aq) ⟶ silver chloride (s) + sodium nitrate (aq)

What is the maximum amount of **silver chloride** that can be formed? [ ] grams

What is the **FORMULA** for the limiting reagent? [ ]

What amount of the excess reagent remains after the reaction is complete? [ ] grams

QUESTION 4.5

Upon reaction of 1.274 g of copper (II) sulfate with excess zinc metal, 0.392 g copper metal was obtained according to the equation:

$$CuSO_4(aq) + Zn(s) \rightarrow Cu(s) + ZnSO_4(aq)$$

What is the percent yield?

GRAVIMETRIC ANALYSIS

A mixture consisting of only **chromium(II) chloride** (**$CrCl_2$**) and **copper(II) chloride** (**$CuCl_2$**) weighs **1.0307** g. When the mixture is dissolved in water and an excess of silver nitrate is added, all the **chloride** ions associated with the original mixture are precipitated as insoluble **silver chloride** (**AgCl**). The mass of the **silver chloride** is found to be **2.2924** g. Calculate the mass percentages of **chromium(II) chloride** and **copper(II) chloride** in the original mixture.

Mass percent **$CrCl_2$** = ______ %

Mass percent **$CuCl_2$** = ______ %