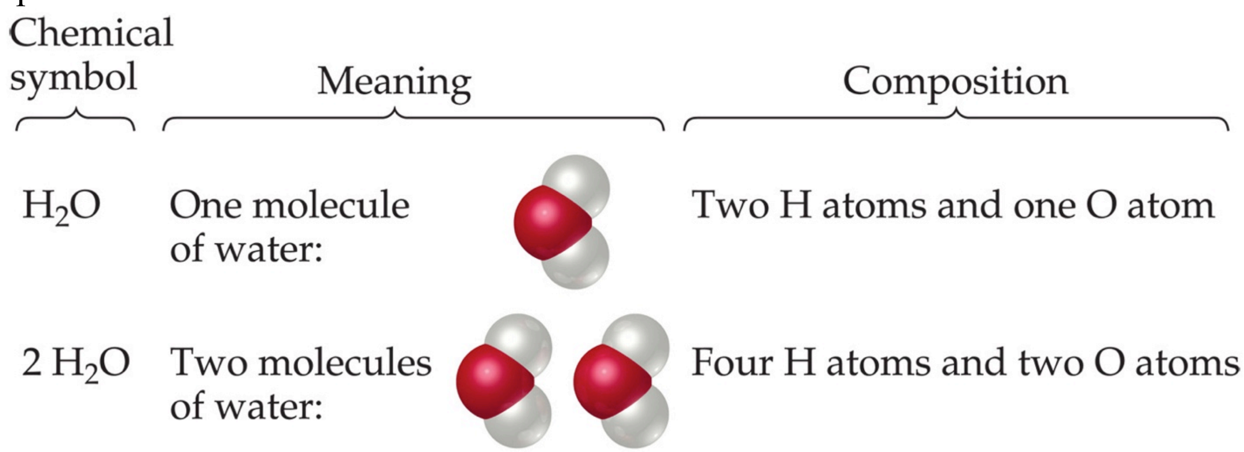
Unit I: Quantitative Relationships
REVIEW:

- Anatomy of a Chemical Equation
  - $CH_{4\,(g)} + 2\ O_{2\,(g)} \rightarrow CO_{2\,(g)} + 2\ H_2O_{(g)}$

- Subscripts and Coefficients Give Different Information



  - Subscripts:
  - Coefficients
- 5 Reaction Types
  - Formation
  - Decomposition
  - Single Replacement
    - Metal replacement
    - Non-metal replacement
  - Double replacement
  - Hydrocarbon combustion
- Review of moles
  - Avogadros Number
  - Molar Mass
  - Mole relationship (mole wheel)
    - Mole to mass

    - Mole to particles

    - Mole to volume for gases at STP & SATP

I. **Stoichiometry**

A. Definitions:

Stoichiometry:

Mole Ratios:

Examples: $N_{2(g)}$ + $3H_{2(g)}$ ----> $2NH_{3(g)}$

- Mole ratio between hydrogen and ammonia is ___________.
- Mole ratio between ammonia and nitrogen is ____________.

B. Types of Stoichiometry:

1) _______________**Stoichiometry**: dealing with molar mass, mass & mole quantities.

2)_______________ **Stoichiometry**: dealing with molar concentration, volume & mole quantities

3) ______**Stoichiometry**: dealing with molar volume, Ideal Gas Law & mole quantities.

C. Stoichiometric Equations can be read as follows:

	$2H_{2(g)}$	+ $O_{2(g)}$	→ $2H_2O_{(g)}$
Molecules or coefficient			
mass (amu)			
mole			
mass (g)			

NOTE: atoms in = atoms out

NOTE: mass in = mass out

D. Solving Stoichiometry Problems in Four Steps

1)

2)

3)

4)

5)

NOTE: Steps ________ are common to all types of stoichiometric methods, while steps __________ vary depending on the given and desired variable units.

Flow Chart

Step 1

Balanced Chemical Equation

p/m/v/C converted to n → multiply by n ratio → converted to m/v/C

Step 2)	Step 3	Step 4
$n = p/6.02 \times 10^{23}$		$p = nP$
$n = m/M$		$m = nM$
$n = v/22.4$ L (STP)		$v = nV$ (STP)
$n = v/24.8$ L (SATP)		$v = nV$ (SATP)
$n = Cv$		$C = n/v$ or $v = n/C$

II. Mole - mole calculations (skip step 2 & 4)

EXAMPLES

1) Nitrogen reacts with hydrogen to form ammonia. Find the number of moles of nitrogen required if 6 moles of ammonia are formed?

2) Find the moles of hydrogen if 0.600 mol of ammonia are produced?

3) Find the moles of water are produced if 6.32 mol of hydrogen is used?

III. Mole - Quantity calculations (skip step 2)

EXAMPLES

1. 5.00 mol of nitrogen reacts with excess hydrogen to form ammonia. How many liters of ammonia are produced at SATP.

2. Aluminum reacts with calcium nitrate. If 0.900 mol of calcium are formed find the mass of aluminum required?

3. 1.20 mol of Cu react with silver nitrate. How many particles of precipitate are produced?

IV. Quantity - Mole calculations (skip step #4)

EXAMPLES:

1. 4.00 L of nitrogen reacts with excess hydrogen to form ammonia. How many moles of ammonia are produced at STP.

2. Iron reacts with oxygen. Find the number of moles of oxygen if 4.0×10^{23} formula units are produced at SATP.

3. 27 g of Sucrose burns. Find the number of moles of water that is produced.

V. Quantity - Quantity calculations (use all 4 steps)

EXAMPLES:

1. Calculate the number of volume of NH_3 produced at STP by a reaction of 5.40g of hydrogen with nitrogen.

2. Find the molecules of hydrogen produced if 24.0 L of water decomposes at SATP conditions.

VI. Limiting Reagents:

- Definition:

- Excess Reagent:

- Overview: When do you worry about limiting reagents?

- Determination:

  Step 1:

  Step 2:

  Step 3:

  Step 4:

  Step 5:

EXAMPLE:

1) $3H_{2(g)} + N_{2(g)}$ ---- $2NH_{3(g)}$

If 2.00 mol of nitrogen were used with 5.00 mol of hydrogen, what would the excess and limiting reagents be?

2) $2Na + Cl_{2(g)} \rightarrow 2NaCl_{(s)}$

There is 6.70 mol of Na and 3.20 mol of Cl_2. What are the limiting and the excess reagents?

3) How many moles are produced when 2.70 mol of ethane reacts with 6.30 mol of oxygen?

4) Iron (III) oxide reacts with carbon monoxide to produce iron and carbon dioxide.

a) If 84.80 g of iron (III) oxide reacted with 31.5 L of carbon monoxide at STP, how many litres of carbon monoxide would be produced?

b) CHALLENGE: How many moles of excess reagent would remain? How many grams?

VII. % Yield:

- Definition:
- Theoretical yield (ideal)
- Actual yield (experimental)
- Formula:
- NOTE: What happens when we have a limiting reagent?

VIII. % Error

- Definition:
- Why is it not 100%?

EXAMPLES:

1) $CaCO_3 \rightarrow CaO_{(s)} + CO_{2(g)}$ What is the % yield if 24.8 g of $CaCO_3$ is heated to produce 13.1 g of CaO?

2) Iron (II) oxide reacts with carbon monoxide to form iron and carbon dioxide. There is 49.3 g of iron produced when 84.8 g of iron oxide reacts with 12.0 L of carbon monoxide at STP. What is the % yield & % error?