**Stoichiometry**

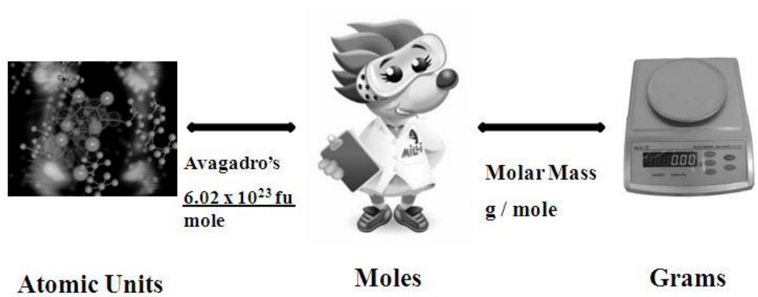
**Stoichiometry**
Calculate quantities of substances in chemical reactions.

For a balanced chemical equation, the Coefficients show:

# formula units that react
mole ratio of reactants & products
(with molar mass) # grams of reactants & products

So far, we have dealt with only one chemical entity. Our solution scheme:

**Mole Map (One Chemical Entity)**




**Avogadro's Number: From Memory**
**Molar Mass: Calculated from Periodic Table**
**Let the Units Drive the Solution!**

But, when we have two chemical entities, our focus must change:

# Think Molar Ratio

## Molecule to Molecule Stoichiometry

**For $2\ C_2H_6 + 7\ O_2 \rightarrow 4\ CO_2 + 6\ H_2O$**

Molecular interpretation:
2 *molecules* $C_2H_6$ (ethane) react with 7 *molecules* $O_2$
to form
4 *molecules* $CO_2$ & 6 *molecules* $H_2O$

**Molar interpretation:**

2 *moles* $C_2H_6$ (ethane) reacts with 7 *moles* $O_2$
to form
4 *moles* $CO_2$ & 6 *moles* $H_2O$

**"per expressions" (Conversion factors)**

These "per expression"

$\frac{2 \text{ moles } C_2H_6}{7 \text{ moles } O_2}$ $\quad$ $\frac{2 \text{ moles } C_2H_6}{4 \text{ moles } CO_2}$ $\quad$ $\frac{2 \text{ moles } C_2H_6}{6 \text{ moles } H_2O}$

Say:

2 moles of $C_2H_6$ corresponds to:
7 moles $O_2$
4 moles $CO_2$
6 moles $H_20$

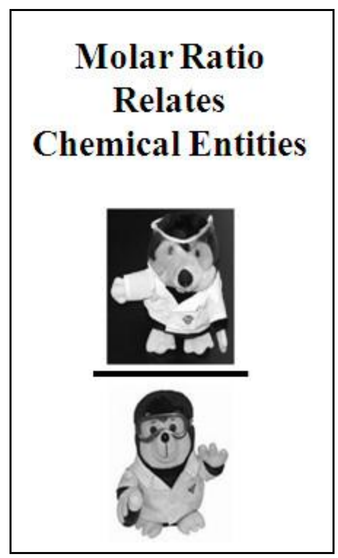
**based on coefficients of balanced equation**

$\frac{2 \text{ moles } C_2H_6}{7 \text{ moles } O_2}$ $\quad$ $\frac{2 \text{ moles } C_2H_6}{6 \text{ moles } H_2O}$ $\quad$ $\frac{2 \text{ moles } C_2H_6}{4 \text{ moles } CO_2}$

$\frac{7 \text{ moles } O_2}{2 \text{ moles } C_2H_6}$ $\quad$ $\frac{7 \text{ moles } O_2}{4 \text{ moles } CO_2}$ $\quad$ $\frac{7 \text{ moles } O_2}{6 \text{ moles } H_2O}$

$\frac{4 \text{ moles } CO_2}{2 \text{ moles } C_2H_6}$ $\quad$ $\frac{4 \text{ moles } CO_2}{7 \text{ moles } O_2}$ $\quad$ $\frac{4 \text{ moles } CO_2}{6 \text{ moles } H_2O}$

$\frac{6 \text{ moles } H_2O}{2 \text{ moles } C_2H_6}$ $\quad$ $\frac{6 \text{ moles } H_2O}{7 \text{ moles } O_2}$ $\quad$ $\frac{6 \text{ moles } H_2O}{4 \text{ moles } CO_2}$



## Mole – Mole Stoichiometry

**For $2\ C_2H_6 + 7\ O_2 \rightarrow 4\ CO_2 + 6\ H_2O$ # moles of $O_2$ required to burn 2.4 moles $C_2H_6$?**

Given = 2.4 moles ethane
Wanted = moles oxygen

Add "per" expression

$$2.4 \text{ moles ethane} \times \frac{7 \text{ moles oxygen}}{2 \text{ moles ethane}} = 8.4 \text{ moles } O_2$$

**Ammonia is formed from its elements.**
**How many moles of hydrogen are needed to produce 4.2 moles ammonia**

**Write Balanced Equation**

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

**Doing the math**

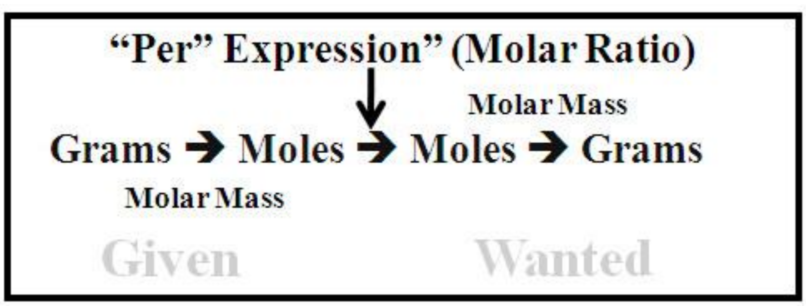
$$4.2 \text{ moles } NH_3 \times \frac{3 \text{ moles } H_2}{2 \text{ moles } NH_3} = 6.3 \text{ moles } H_2$$

## Mass-Mass Stoichiometry

**Types of problems that coefficients + molar mass solve:**
grams (given) → moles (wanted)
moles (given) → moles (wanted)
moles (given) → grams (wanted)
grams (given) → grams (wanted)

**Universal Scheme:**

**Mass (given) → Moles (given) → Moles (wanted) → Mass (wanted)**




Just another
What is known?
What is wanted?
How do I get there by "canceling units"? Type problem

## Mass-Mole Stoichiometry

**For $C_2H_4$ + 3 $O_2$ → 2 $CO_2$ + 2 $H_2O$ How many moles of oxygen are used to form 43.7 g $H_2O$?**

**Given = 43.7 grams water**
**Wanted = moles oxygen**

43.7 g $H_2O$ = moles $O_2$

**Since grams given, must determine molar mass:**
For water: 18.02 g/mole

$$43.7 \text{ g } H_2O \times \frac{1 \text{ mole } H_2O}{18.02 \text{ g}} \times \frac{3 \text{ mole } O_2}{2 \text{ mole } H_20} = \text{moles } O_2$$

**Do the math**

$$43.7 \text{ g } H_2O \times \frac{1 \text{ mole } H_2O}{18.02 \text{ g}} \times \frac{3 \text{ mole } O_2}{2 \text{ mole } H_20} = 3.63 \text{ moles } O_2$$

## Mole-Mass Stoichiometry

**For $C_2H_4$ + 3 $O_2$ → 2 $CO_2$ + 2 $H_2O$ How many grams of $CO_2$ form by burning 0.739 mol $C_2H_4$?**

**Given = 0.739 mol ethylene**
**Wanted = grams carbon dioxide**

0.739 mol $C_2H_4$ = # g $CO_2$

**Since grams needed, must determine molar mass:**
For carbon dioxide: 44.01 g/mole

**Add the "per" expression**

$$0.739 \text{ mol } C_2H_4 \times \frac{2 \text{ mol } CO_2}{1 \text{ mol } C_2H_4} \times \frac{44.01 \text{ g}}{1 \text{ mole } CO_2} = \# \text{ g } CO_2$$

**Do the math**

$$0.739 \text{ mol } C_2H_4 \times \frac{2 \text{ mol } CO_2}{1 \text{ mol } C_2H_4} \times \frac{44.01 \text{ g}}{1 \text{ mole } CO_2} = 65.0 \text{ g } CO_2$$

## Mass-Mass Stoichiometry

**#How grams of oxygen required to burn 155 g ethane?**

**Write Balanced Equation**

**$2\ C_2H_6 + 7\ O_2 \rightarrow 4\ CO_2 + 6\ H_2O$**

**For ethane: 30.07 g/mole ; For oxygen: 32.00 g/mole**

**From moles ethane, to moles $O_2$**

$155\ g\ C_2H_6 \times \frac{1\ mole\ C_2H_6}{30.07\ g} \times \frac{7\ Moles\ O_2}{2\ Moles\ C_2H_6} =$ # grams oxygen

**From moles oxygen, to grams oxygen, when units correct, Do the math:**

$155\ g\ C_2H_6 \times \frac{1\ mol\ C_2H_6}{30.07\ g} \times \frac{7\ Mol\ O_2}{2\ Mol\ C_2H_6} \times \frac{32.00\ g}{1\ mol} = 577\ g\ O_2$

**For $4\ Al + 3\ O_2 \rightarrow 2\ Al_2O_3$**
**How many moles of aluminum oxide are formed from 8 moles of aluminum?**

**Given = 8 moles Al**
**Wanted = moles aluminum oxide**

$8\ moles\ Al \times \frac{2\ moles\ Al_2O_3}{4\ moles\ Al} = 4\ moles\ Al_2O_3$

**For $4\ Al + 3\ O_2 \rightarrow 2\ Al_2O_3$ How many moles of $O_2$ are needed to react with 1.7 moles of Al?**

**Given = 1.7 moles Al**
**Wanted = moles oxygen**

$1.7\ moles\ Al \times \frac{3\ moles\ Oxygen}{4\ moles\ Al} = 1.3\ moles\ O_2$

**For $4\ Al + 3\ O_2 \rightarrow 2\ Al_2O_3$**
**How many grams of Al must react with $O_2$ to form 43.6 grams of $Al_2O_3$?**

**Given = 43.6 grams $Al_2O_3$**
**Wanted = grams Al**

$43.6\ g\ Al_2O_3$ = # g Al

**Since grams given, must determine molar mass:**
**Al = 26.98 g/mole; $Al_2O_3$= 101.96 g/mole**

$43.6\ g\ Al_2O_3 \times \frac{1\ mole\ Al_2O_3}{101.96\ g} \times \frac{4\ moles\ Al}{2\ moles\ Al_2O_3} \times \frac{26.98\ g\ Al}{1\ mole} = 23.1\ g\ Al$

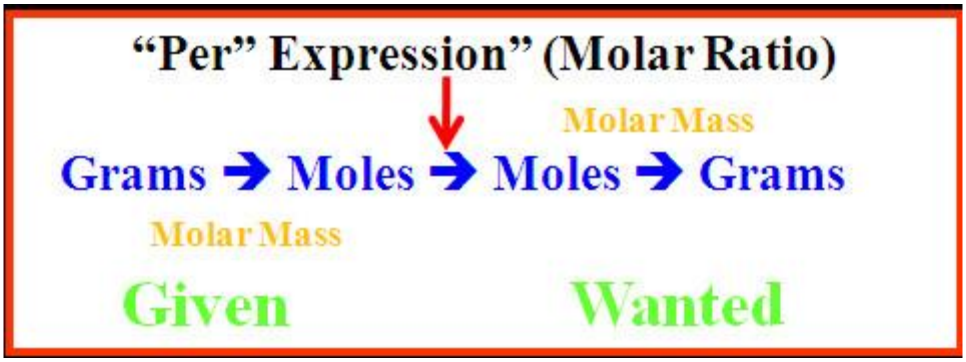
**Stoichiometry can be extended to any desired quantity**

If the density of water is 1.00 g/mL, how many mL of $H_2O$ are produced when 6.70 moles of $HNO_3$ reacts with KOH?

$$HNO_{3(aq)} + KOH_{(aq)} \rightarrow KNO_{3(aq)} + H_2O_{(l)}$$

$$6.70 \text{ mol } HNO_3 \times \frac{1 \text{ mol } H_2O}{1 \text{ mol } HNO_3} \times \frac{18.02 \text{ g } H_2O}{1 \text{ mol } H_2O} \times \frac{1 \text{ mL } H_2O}{1.00 \text{ g } H_2O} = 121 \text{ g}$$

**Generalized Path: Starting From a Balanced Chemical Reaction:**




**Assignment**

Start Taking Unit 7 Practice Test
Blackboard only records highest score
Take until multiple 100's have been scored (questions are variable)
(Gives sense of test exam format and content)

**The Practice Quiz is very similar to the Unit Exam**
**Success on Unit exam is directly related to practice exam experiences**