STOICHIOMETRY

Stoikheion = element; *metron* = to measure

STOICHIOMETRY

Chemists use balanced chemical equations to calculate how much reactant is needed or how much product is formed.

- provides the same kind of quantitative information that a recipe does.

STOICHIOMETRY is….

- Calculation of the quantities of **reactants** and **products** in a chemical reaction.
- The study of the *quantitative* relationships between the amounts of **reactants** and **products** in a chemical reaction.
- Based on the Law of **Conservation of Mass**
  - **MASS and the NUMBER OF ATOMS are conserved in every chemical reaction.**

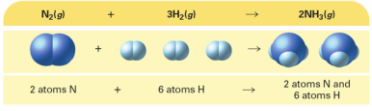
Interpreting Chemical Equations

- A balanced chemical equation can be interpreted in terms of different quantities, including numbers of atoms, molecules, or moles; mass; and volume.

$$N_2(g) + 3H_2(g) \longrightarrow 2\,NH_3(g)$$

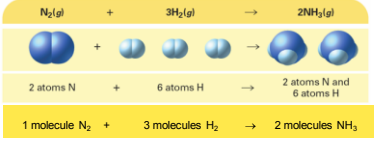
Interpreting Chemical Equations

Number of Atoms



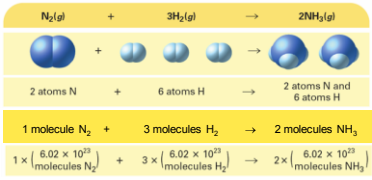
Interpreting Chemical Equations

Number of Molecules



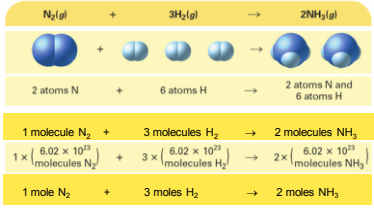
Interpreting Chemical Equations

Number of Molecules



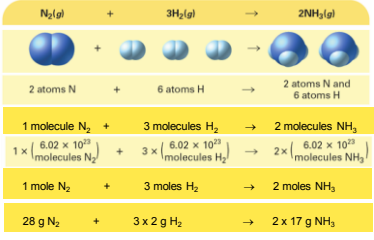
Interpreting Chemical Equations

Moles



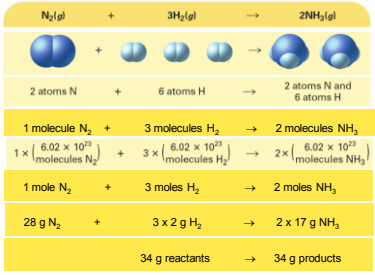
Interpreting Chemical Equations

Mass



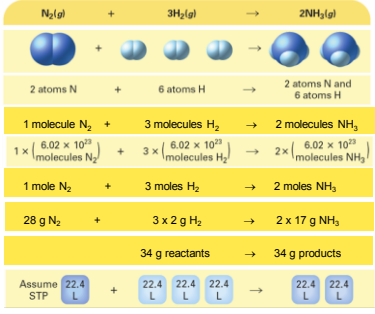
Interpreting Chemical Equations

Mass



Interpreting Chemical Equations

Volume



Mole Ratios in Chemical Reactions

- The ratio between the coefficients of any two compounds in a balanced chemical reaction.

EXAMPLE: $4\ Fe\ (s) + 3\ O_2\ (g) \rightarrow 2\ Fe_2O_3\ (s)$

$$\frac{4\ mol\ Fe}{2\ mol\ Fe_2O_3} \qquad \frac{4\ mol\ Fe}{3\ mol\ O_2} \qquad \frac{3\ mol\ O_2}{2\ mol\ Fe_2O_3}$$

$$\frac{3\ mol\ O_2}{4\ mol\ Fe} \qquad \frac{2\ mol\ Fe_2O_3}{4\ mol\ Fe} \qquad \frac{2\ mol\ Fe_2O_3}{3\ mol\ O_2}$$

Stoichiometry Vocabulary

- *Stoikheion* = element; *metron* = to measure
- Study of the quantitative relationships in chemical formulas & equations
- Review: a mole (mol) is a certain number of things (atoms, ions or molecules) = to 6.02×10^{23}
- Coefficients in the balanced equation tell you how many moles of each reactant and product are needed

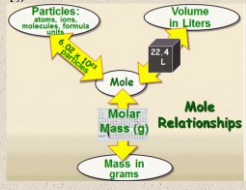
Stoichiometry Vocabulary

- Review: formula or molar mass is found by adding the atomic masses on the periodic table (round to the tenths place)
- Molar volume (measured at STP "standard temperature & pressure") of any gas is equal to 22.4 L

Chapter 11 v. Chapter 12

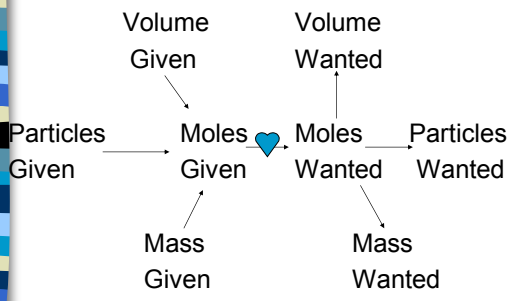
In Chapter 11, we converted amounts of the SAME substance to different units (moles, particles, L or g).

In Chapter 12, we will be looking at chemical equations and calculating amounts of a substance using a given amount of a DIFFERENT substance.



Mole ratios are the HEART ♥ of every stoichiometry problem.

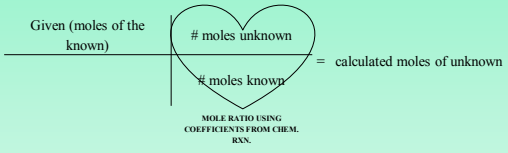
Mole Map



Mole Map

Mole-Mole Conversions

Mole ratios are the HEART of every stoichiometry problem.



The mole ratio you use depends on what substance your given is ("known") and which substance you want to calculate ("unknown")

Mole-Mole Conversions - Example

$1\ N_2 + 3\ H_2 \rightarrow 2\ NH_3$

- Problem: If I have **2 moles of N_2** and excess H_2, how many **moles of NH_3** can I make?

"KNOWN" (given): **2 moles N_2**

"UNKNOWN": **moles NH_3**

MOLE RATIO: $\frac{\text{moles "unknown"}}{\text{moles "known"}} = \frac{2 \text{ moles } NH_3}{1 \text{ mole } N_2}$

Mole-Mole Conversions - Example

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

Given (moles of the known) × (# moles unknown / # moles known) = calculated moles of unknown

MOLE RATIO USING COEFFICIENTS FROM CHEM. RXN.

$2 \text{ moles } N_2 \times \frac{2 \text{ moles } NH_3}{1 \text{ mole } N_2} = 4 \text{ moles } NH_3$

Mole-Mole Conversions - Example

$2\ H_2 + 1\ O_2 \rightarrow 2\ H_2O$

- Problem: If I have **8 moles of O_2** and excess H_2, how many **moles of H_2O** can I make?

"KNOWN" (given): **8 moles O_2**

"UNKNOWN": **moles H_2O**

MOLE RATIO: [redacted]

Mole-Mole Conversions - Example

$$2\ H_2 + O_2 \rightarrow 2\ H_2O$$

Given (moles of the known) $\times$ (# moles unknown / # moles known) = calculated moles of unknown

MOLE RATIO USING COEFFICIENTS FROM CHEM. RXN.

$$8 \text{ moles } O_2 \times \frac{2 \text{ moles } H_2O}{1 \text{ mole } O_2} = 16 \text{ moles } H_2O$$

Mole-Mole Calculations – You try…

$$4\ Al + 3\ O_2 \rightarrow 2\ Al_2O_3$$

•If I have 12 moles of Al_2O_3 how many moles of O_2 do I need?

1. KNOWN: 12 moles Al_2O_3 UNKNOWN: moles O_2
2. Mole ratio: $\frac{\text{moles unknown}}{\text{moles known}} = \frac{3 \text{ moles } O_2}{2 \text{ moles } Al_2O_3}$
3. Calculate unknown: $12 \text{ moles } Al_2O_3 \times \frac{3 \text{ moles } O_2}{2 \text{ moles } Al_2O_3} = 18 \text{ moles } O_2$

Mole Map

Mass Given → Moles Given → Moles Wanted → Mass Wanted

Mole-Mass Conversions

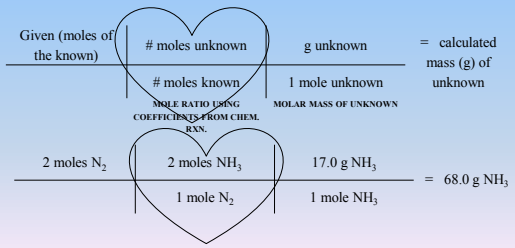
Conversion if you *know* the number of <u>moles</u> of a reactant or product in a reaction and you *want to calculate* the <u>mass</u> of another product or reactant.

Mole-Mass Calculations - Example

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

Problem:

- If I have 2 moles of N_2 and excess H_2, how many grams of NH_3 can I make?

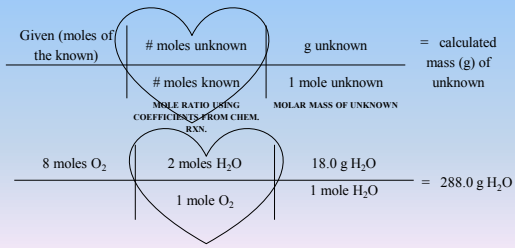


Mole-Mass Calculations - Example

$2\ H_2 + O_2 \rightarrow 2\ H_2O$

Problem:

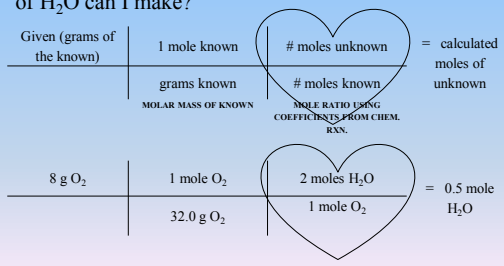
- If I have 8 moles of O_2 and excess H_2, how many grams of H_2O can I make?



Mass-Mole Calculation - Example

Problem: $2\ H_2 + O_2 \rightarrow 2\ H_2O$

- If I have 8 grams of O_2 and excess H_2, how many moles of H_2O can I make?

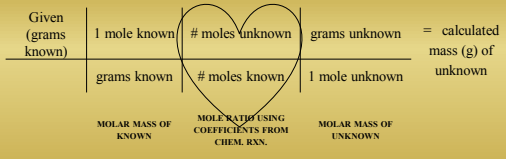


Mole Map

Mass Given → Moles Given → Moles Wanted → Mass Wanted

Mass-Mass Conversions

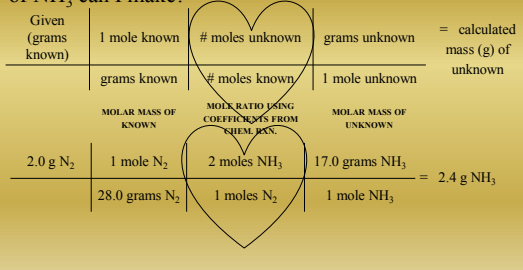
Conversion if you *know* the <u>mass</u> of a reactant or product in a reaction and you *want to calculate* the <u>mass</u> of another product or reactant.



Mass-Mass Calculations - Example

Problem: $N_2 + 3\ H_2 \rightarrow 2\ NH_3$

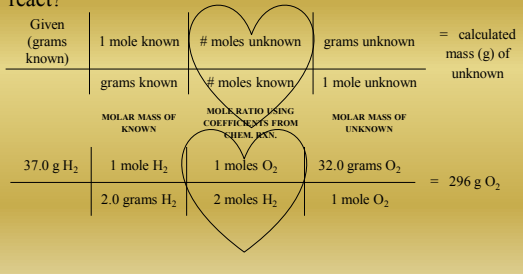
- If I have 2.0 grams of N_2 and excess H_2, how many grams of NH_3 can I make?



Mass-Mass Calculations - Example

Problem: $2\ H_2 + O_2 \rightarrow 2\ H_2O$

- If I have 37.0 grams of H_2, how many grams of O_2 will react?



Mass-Mass Calculations - Example

Problem: $2\ H_2 + O_2 \rightarrow 2\ H_2O$

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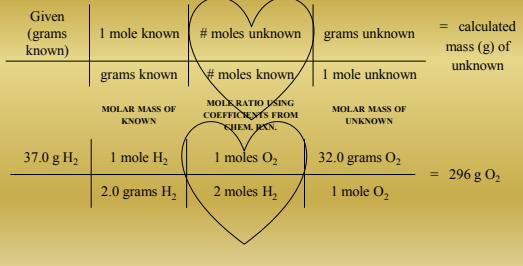


Mole Map

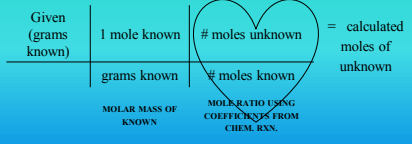
Mass Given → Moles Given ♥ Moles Wanted → Mass Wanted

Mixed Stoichiometry Calculations

Problem: $2\ H_2 + O_2 \rightarrow 2\ H_2O$

- If I have 37.0 grams of H_2, how many moles of O_2 will react?

Mass Given → Moles Given ♥ Moles Wanted → Mass Wanted

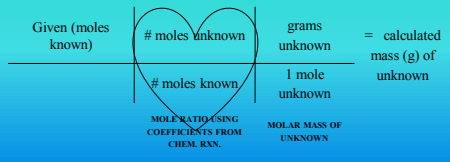


Mixed Stoichiometry Calculations

Problem: $2\ H_2 + O_2 \rightarrow 2\ H_2O$

- If I have 2.0 moles of H_2, how many grams of O_2 will react?

Mass Given → Moles Given ♥ Moles Wanted → Mass Wanted



Mixed Stoichiometry Calculations

Problem: $2\ H_2 + O_2 \rightarrow 2\ H_2O$

- If I have 2.0 moles of H_2, how many moles of O_2 will react?

Mass Given → Moles Given → Moles Wanted → Mass Wanted

Given (moles known) | # moles unknown / # moles known = calculated moles of unknown

MOLE RATIO USING COEFFICIENTS FROM CHEM. RXN.

Mixed Stoichiometry Calculations

Problem: $2\ H_2 + O_2 \rightarrow 2\ H_2O$

- If I have 37.0 grams of H_2, how many grams of O_2 will react?

Mass Given → Moles Given → Moles Wanted → Mass Wanted

Given (grams known) | 1 mole known / grams known | # moles unknown / # moles known | grams unknown / 1 mole unknown = calculated mass (g) of unknown

MOLAR MASS OF KNOWN

MOLE RATIO USING COEFFICIENTS FROM CHEM. RXN.

MOLAR MASS OF UNKNOWN