Warm-Up | Stoichiometric Calculations

Lesson Objectives

By the end of this lesson, you should be able to:

- Use molar mass to write conversion factors that convert between mass and moles.
- Identify and solve [ ] problems that relate mass to moles and mass to mass.
- Perform stoichiometric calculations to determine mass relationships between reactants and products of a reaction.

Science Practice: Use mathematical procedures, including dimensional analysis and significant [ ], when solving mole-to-mass, mass-to-mole, and mass-to-mass stoichiometric problems.

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Lesson Question

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Molar Mass and Mass-to-Mole Ratio

- Molar mass = [ ] (g)/mole (mol)
  - Example: NaCl: 58.44 g/mol $58.44\ \text{g NaCl/mol} = \frac{58.44\ \text{g NaCl}}{\square\ \text{NaCl}}$
- Use as conversion [ ]

$$\frac{58.44\ \text{g NaCl}}{1\ \text{mol NaCl}}$$

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The Mole-to-Mass Ratio

- Invert conversion factor for reverse conversion:

$$\frac{159.7\ \text{g } Fe_2O_3}{1\ \text{mol } Fe_2O_3} \xrightarrow{\text{invert}} \frac{1\ \text{mol } \square}{159.7\ \text{g } Fe_2O_3}$$

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How to Convert Number of Moles to Mass

Calculate the mass of 2.75 mol Fe_2O_3. (Molar [ ] of $Fe_2O_3 = 159.7$ g/mol)

- Write [ ] conversion using [ ] analysis.

$$2.75 \text{ mol } Fe_2O_3 \times \frac{[\ ]\ Fe_2O_3}{1 \text{ mol } Fe_2O_3}$$

- Cancel like terms and units.

$$2.75 \cancel{\text{ mol } Fe_2O_3} \times \frac{159.7 \text{ g } Fe_2O_3}{1 \cancel{\text{ mol } Fe_2O_3}} = ? \text{ g } Fe_2O_3$$

- Solve (remember significant [ ] !).

$$2.75 \cancel{\text{ mol } Fe_2O_3} \times \frac{159.7 \text{ g } Fe_2O_3}{1 \cancel{\text{ mol } Fe_2O_3}} = [\ ] \text{ g } Fe_2O_3$$

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How to Convert Number of Moles to Mass

- Write unit conversion using dimensional analysis.
- Cancel like terms and units.
- Solve (remember significant figures!).

Number of moles of [ ] × Conversion factor (molar mass) = Mass of substance

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How to Convert Mass to Number of Moles

Calculate the number of moles of Al_2O_3 present in 23.87 g. (Molar mass of $Al_2O_3 = 102.0$ [ ])

- Write unit conversion using dimensional analysis.

$$23.87\ g\ Al_2O_3 \times \frac{1\ mol\ [\ ]}{102.0\ g\ Al_2O_3}$$

- Cancel like terms and units.

$$23.87\ \cancel{g\ Al_2O_3} \times \frac{1\ mol\ Al_2O_3}{102.0\ \cancel{g\ Al_2O_3}} = ?\ mol\ Al_2O_3$$

- Solve (remember significant figures!).

$$23.87\ \cancel{g\ Al_2O_3} \times \frac{1\ mol\ Al_2O_3}{102.0\ \cancel{g\ Al_2O_3}} = [\ ]\ mol\ Al_2O_3$$

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How to Convert Mass to Number of Moles

- Write unit conversion using dimensional analysis.
- Cancel like terms and units.
- Solve (remember [ ] figures!).

Mass of substance × **Conversion factor (inverse molar mass)** = **Number of moles of substance**

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How to Find the Mass of a Product Given the Mass of a Reactant

- Convert mass of [ ] to moles of reactant.
- Convert moles of reactant to moles of product.
- Convert moles of product to mass of product.

$$\text{g reactant} \times \frac{\text{mol reactant}}{\text{g reactant}} \times \frac{\text{mol product}}{\text{mol reactant}} \times \frac{\text{g product}}{\text{mol product}} = \text{g product}$$

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How to Find the Mass of a Product Given the Mass of a Reactant

What mass of iron (☐) can form when 59.27 g Fe_2O_3 reacts completely according to the balanced chemical equation below?

$$Fe_2O_3 + 2Al \rightarrow Al_2O_3 + 2Fe$$

- Strategy:
  - Set up conversion.
  - Cancel like units.
  - Solve.

How to Find the Mass of a Product Given the Mass of a Reactant

What mass of iron (Fe) can form when 59.27 g Fe_2O_3 reacts completely according to the balanced chemical equation below? Use the periodic table to find molar masses.

$$2Al + Fe_2O_3 \rightarrow 2Fe + Al_2O_3$$

$$59.27\ \text{g}\ Fe_2O_3 \times \frac{1\ \text{mol}\ Fe_2O_3}{159.7\ \text{g}\ Fe_2O_3} \times \frac{2\ \text{mol Fe}}{1\ \text{mol}\ Fe_2O_3} \times \frac{\square\ \text{Fe}}{1\ \text{mol Fe}} = ?\ \text{g Fe}$$

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What mass of iron (Fe) can form when 59.27 g Fe_2O_3 reacts completely according to the balanced chemical equation below? Use the periodic table to find molar masses.

$$2Al + Fe_2O_3 \rightarrow 2Fe + Al_2O_3$$

$$\square\ g\ Fe_2O_3 \times \frac{1\ mol\ Fe_2O_3}{159.7\ g\ Fe_2O_3} \times \frac{2\ mol\ Fe}{1\ mol\ Fe_2O_3} \times \frac{55.85\ g\ Fe}{1\ mol\ Fe} = \square\ g\ Fe$$

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How to Find the Mass of a Reactant Given the Mass of Another Reactant

A chemist reacts hydrogen gas (H_2) and oxygen gas (O_2) to form water according to this balanced chemical equation: $2H_2 + O_2 \rightarrow 2\square$.

If the chemist has 50.00 g O_2, what mass of hydrogen must be used to react completely with the oxygen? Use the periodic table to find molar masses.

Given: Mass of oxygen Desired: Mass of hydrogen

$$50.00\ g\ O_2 \times \frac{1\ mol\ O_2}{32.00\ g\ O_2} \times \frac{2\ mol\ H_2}{1\ mol\ O_2} \times \frac{2.02\ g\ H_2}{1\ mol\ H_2} = \square\ g\ H_2$$

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How to Convert between Masses of Reactants and Products

- Use the same process for all of the following:
  - Calculate mass of ☐ formed from given mass of reactant
  - Calculate mass of one reactant needed to react fully with another
  - Calculate mass of one product produced given mass of another
  - Calculate mass of reactant needed to form given mass of product

$$\text{g } \square \times \frac{\text{mol given}}{\text{g given}} \times \frac{\text{mol desired}}{\text{mol given}} \times \frac{\text{g desired}}{\text{mol desired}} = \square \text{ desired}$$

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Lesson Question

How do you calculate the amount of reactants and products in a chemical reaction?

Answer

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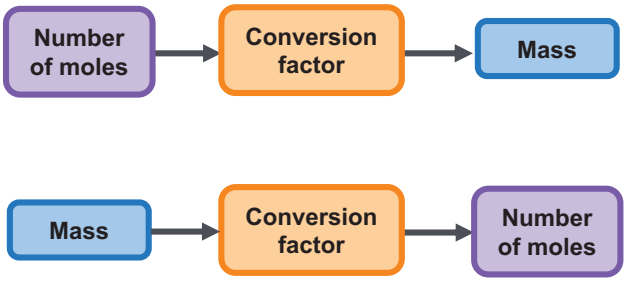
The Molar Mass Conversion Factor

Molar mass can be used as a conversion factor to convert either number of moles to [ ] or mass to number of moles.



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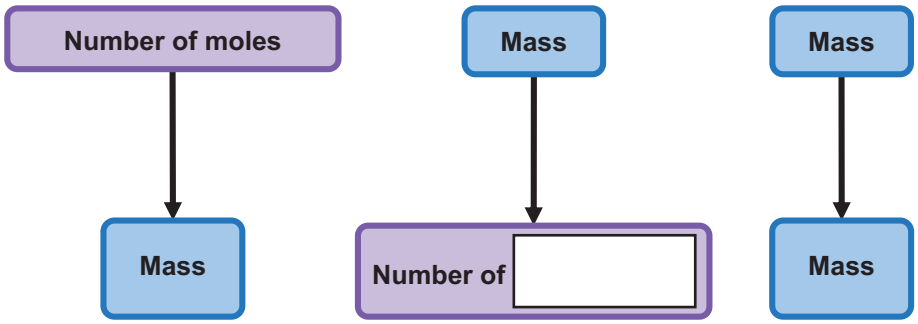
Calculating Quantities

Molar ratios from a [ ] chemical equation, together with molar mass, can be used to calculate the mass or number of moles of one substance that corresponds to a given quantity of another substance in the reaction.

$$\text{g given} \times \frac{\text{mol given}}{\text{g given}} \times \frac{\text{mol desired}}{\text{mol given}} \times \frac{\text{g desired}}{\text{mol desired}} = \text{g desired}$$

Dimensional Analysis

Dimensional analysis is the basis of stoichiometric calculations.



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