Unit 2: Quantities in Chemistry

Section: 2.1 – 2.14
Pages 80-163

Mass, Moles, & Molar Mass

Term	Definition
	Relative quantities of isotopes in a natural occurring element (%)

E.g. Carbon has 2 isotopes C-12 and C-13. Of Carbon's two isotopes, there is 98.9% C-12 and 1.11% C-13. Find the average atomic mass of Carbon.

Term	Definition
	The mass of one molecule of an ionic compound in a.m.u.

E.g. Calculate the formula mass of $CaCl_2$.

The Mole

Term	Definition
	6.023×10^{23} entities
	The number of entities in one mole, 6.023×10^{23}
	The mass, in grams, of one mole of a chemical entity

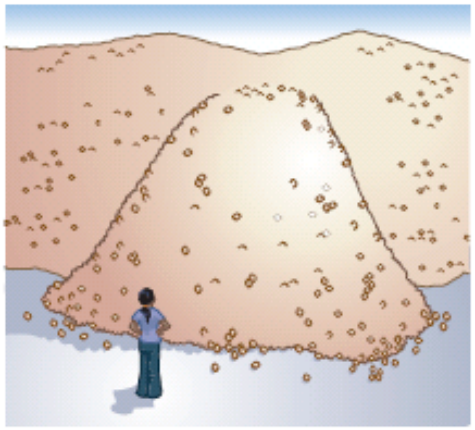


Figure 5
One mole of eggs would cover the entire surface of Earth to a depth of over 60 km.

E.g. Calculate the molar mass of NaCl.

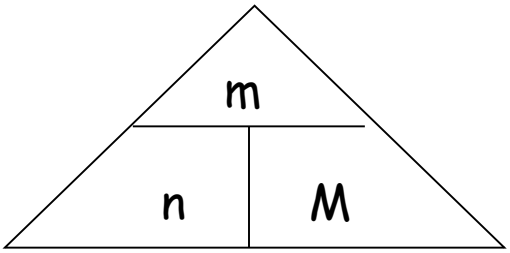
Table 4 Grouping Entities: Moles of Water Molecules

Individual entities	$2\ H_{2(g)} + 1\ O_{2(g)} \rightarrow 2\ H_2O_{(l)}$
Multiples of 6.02×10^{23}	$2\ (6.02 \times 10^{23})\ H_{2(g)} + 1\ (6.02 \times 10^{23})\ O_{2(g)} \rightarrow 2\ (6.02 \times 10^{23})\ H_2O_{(l)}$
Multiples of a mole	$2\ \text{mol}\ H_{2(g)} + 1\ \text{mol}\ O_{2(g)} \rightarrow 2\ \text{mol}\ H_2O_{(l)}$

Calculations Involving the Mole

Table 5 Quantity Symbols and Units

Symbol	Quantity	Unit
n	amount (in moles)	mol
m	mass	mg, g, kg
M	molar mass	g/mol
N	number of entities	atoms, ions, formula units, molecules
N_A	Avogadro's constant, 6.03×10^{23}	—



n -

m-

M -

E.g., Calculate the mass, in grams, of 2.00 moles of calcium atoms.

E.g. What amount of gold is in a 275.8g nugget of pure gold? And how many atoms does this represent?

Calculations Involving the Mole Continued.

Calculate the mass of 1 mol of sodium hydrogen carbonate (baking soda), $NaHCO_3$.

Sodium fluoride is added to toothpaste and tap water to prevent tooth decay. Calculate the mass of 2.00 mol of sodium fluoride, $NaF_{(s)}$

How many water molecules are in a 25.0g sample of water, $H_2O_{(l)}$?

Determining Empirical Formulas

Term	Definition
	A compound contains elements in certain fixed proportions. E.g. NaCl, H_2O, $C_6H_{12}O_6$
	The percentage, by mass, of each element in a compound.
	A formula that gives the lowest ratio of the atoms in a compound

The percentage composition of a compound was found to be 69.9% iron and 30.1% oxygen. What is the empirical formula of the compound.

Step 1: Percent to Mass: Calculate Mass (m) of each element in a 100 g sample. "Assume a 1 mol sample"

Step 2: Mass to Mole: Convert Mass (m) into Amount in moles (n)

Step 3: Divide by Small: Divide ALL mole answers in step 2 by smallest value.

Step 4: Multiply 'til whole: If any answer in step 3 ends with a .5, then multiply all answers in step 3 by "2"

Determining Molecular Formulas

Term	Definition
	A formula that indicates the actual number of atoms in one molecule of a compound.

The empirical formula of a compound is CH_3O, and its molar mass is 93.12 g/mol (determined by a mass spectrometer). What is the molecular formula of the compound?

Step 1: List given values.

Step 2: Determine Molar Mass of the Empirical Formula.

Step 3: Determine the multiple. A ratio of the Molar Mass of Compound to Molar Mass of Empirical Formula.

Step 4: Calculate Molecular Formula. Apply the multiple to all subscript numbers in the EF.

Determining Percent Composition

Calculate the percentage composition of potassium sulfate, K_2SO_4.

Step 1: If given a formula only, you must "Assume a 1 mol sample".

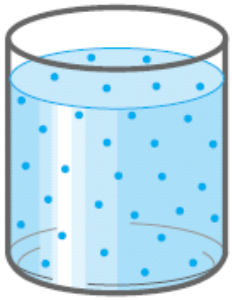
Step 2: Calculate the Total Mass of Each Element in the Compound.

Step 3: Calculate Molecular Mass (or formula unit mass) of Compound.

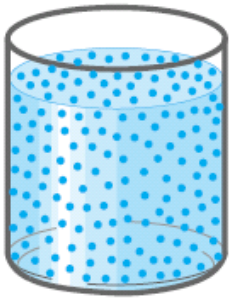
Step 4: Calculate Percentage Composition by Mass of Compound.

% Concentration V/V, M/V

Term	Definition
	Measurement of a quantity of a chemical entity.
	A ratio of the quantity of solute in a solution.



(a) dilute solution



(b) concentrated solution

$$c_{\text{solution}} = \frac{v_{\text{solute}}}{v_{\text{solution}}} \times 100\%$$

where c_{solution} is the concentration of the solution
v_{solute} is the volume of solute in the solution
v_{solution} is the volume of the solution

For weight by volume (W/V) concentrations,

$$c_{\text{solution}} = \frac{m_{\text{solute}}}{v_{\text{solution}}} \times 100\%$$

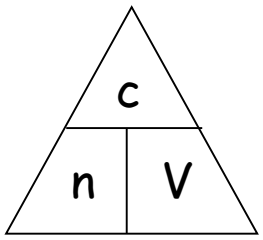
where c_{solution} is the concentration of the solution
m_{solute} is the mass of solute in the solution
v_{solution} is the volume of the solution

A salt solution is formed by mixing 2.80 g of $NaCl_{(s)}$, in enough water to make exactly 250 mL of solution. What is the W/V percentage concentration of sodium chloride salt solution?

Step 1: List Given Values.

Step 2: Write Percentage Concentration Equation, Substitute Values, & Solve.

Molar Concentration



c – is the molar concentration in mol/L.

n – is the amount of solute in moles.

V – is the volume of the solution in L.

A sodium hydroxide solution contains 0.186 mol of sodium hydroxide in 0.250 L of solution. Calculate the molar concentration of the sodium hydroxide solution.

Step 1: List Given Values.

Step 2: Write Molar Concentration Equation, Substitute Values, & Solve.

Parts Per Million

Term	Definition
	Concentration unit that is used for very low concentrations; one part solute for every million parts of solvent.

1 ppm = approximately 1 drop in a full bathtub

1 ppb = approximately 1 drop in a full swimming pool

1 ppt = approximately 1 drop in 1000 swimming pools

In a chemical analysis 2.2 mg of oxygen was measured in 250 mL of pond water. What is the concentration of oxygen in ppm?

Step 1: List Given Values.

Step 2: Write Percentage Composition Equation.

Step 3: Substitute Values into Equation and Solve.

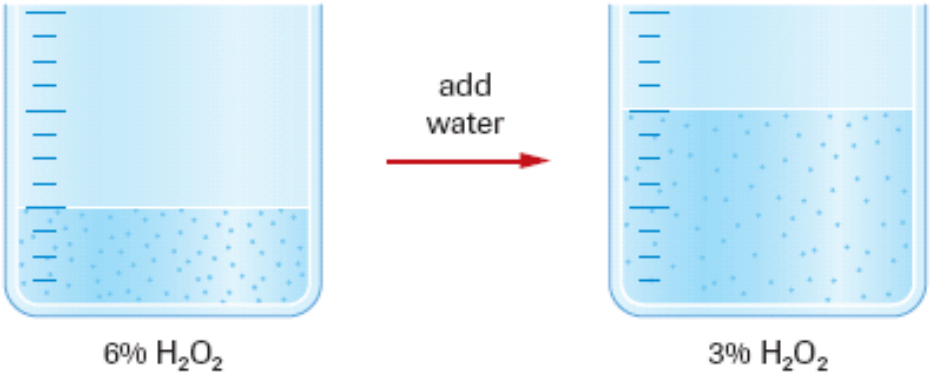
Concentrations of Solutions Summary!

SUMMARY **Concentration of a Solution Equations**

Type	Equation	Units
percentage V/V	$c = \frac{v_{\text{solute}}}{v_{\text{solution}}} \times 100\%$	% V/V
percentage W/V	$c = \frac{m_{\text{solute}}}{v_{\text{solution}}} \times 100\%$	% W/V
very low (number)	$c = \frac{m_{\text{solute}}}{v_{\text{solution}}} \times 100\%$	mg/L = ppm µg/L = ppb ng/L = ppt
molar	$c = \frac{n_{\text{solute}}}{v_{\text{solution}}} \times 100\%$	mol/L

Diluting Aqueous Solutions

Term	Definition
	The process of decreasing the concentration of a solution by adding more solvent.



C_1 – initial concentration $C_1V_1 = C_2V_2$ C_2 – final concentration

V_1 – initial volume V_2– final volume

Calculate the final volume of a hydrogen peroxide solution if water is added to a 100 mL of 6% V/V hydrogen peroxide solution until it reaches a volume of 250 mL.

Step 1: List Given Values.

Step 2: Write Dilution Equation.

Step 3: Isolate Unknown Value on Left-Hand Side.

Step 4: Substitute Values in & Solve.

Stoichiometry

Term	Definition
	The ratio of amount, in moles, of reactants and products in a chemical reaction.
	Mathematical procedures for calculating the quantities of reactants and products involved in chemical reactions.

Propane, $C_3H_{8(g)}$, is a gas that is commonly used in barbecues. Calculate the mass of oxygen that is required to burn 15.0 g of propane.

Step 1: Balance Equation, List Given Values and Molar Masses.

Step 2: Convert Mass of a Given Substance to an Amount (moles).

Step 3: Convert Amount of a Given Substance to Amount Required of a Given Substance using a MOLAR RATIO.

Step 4: Convert Amount of Required Substance to Required Value.

Step 5: Write a therefore statement that answers the question.

Summary of Stoichiometry!

Figure 1 summarizes the steps in a stoichiometric calculation.

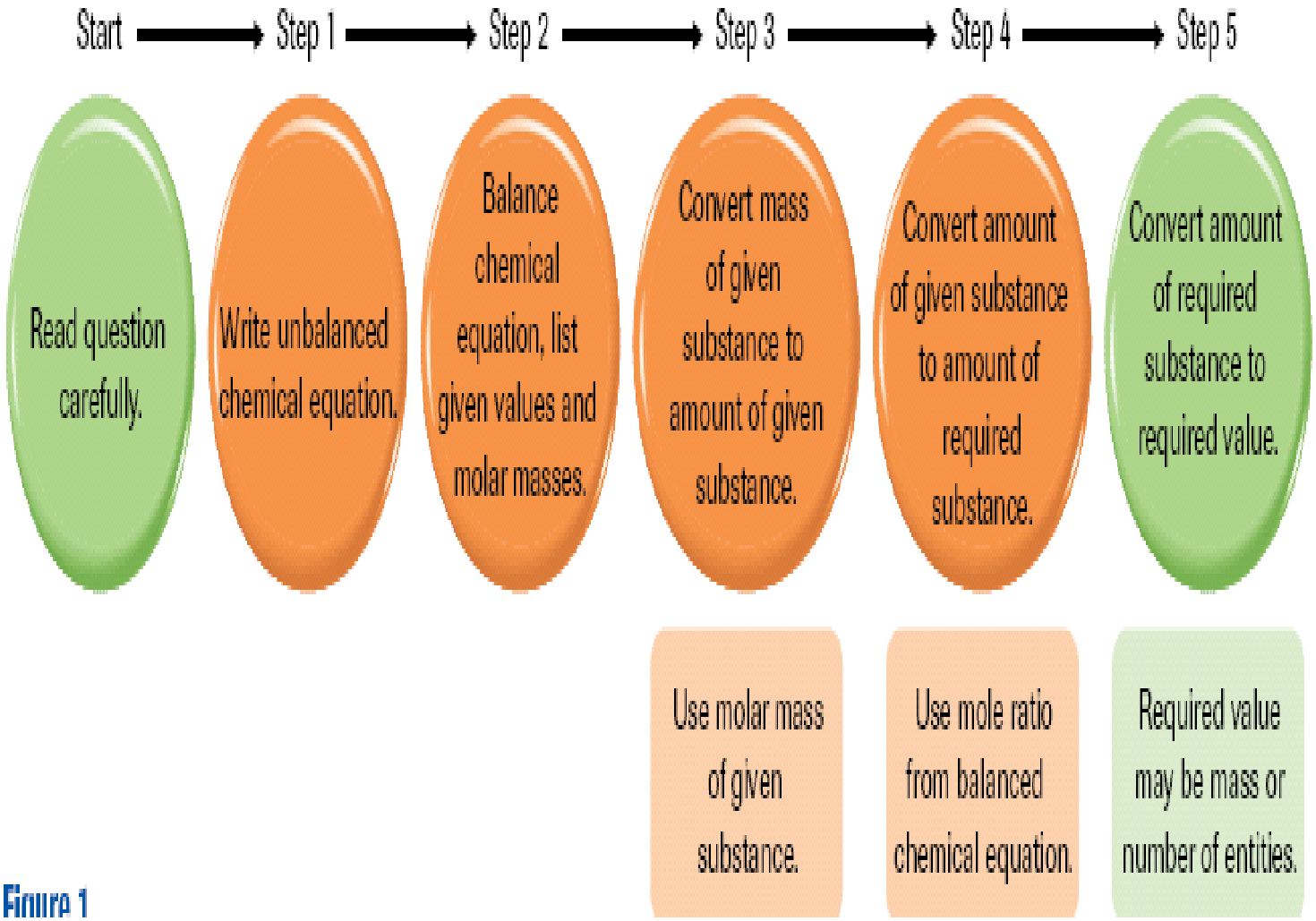


Figure 1

Limiting & Excess Reagents

Term	Definition
	The reactant that is totally consumed in a chemical reaction.
	The reactant that is present in more than the required amount in a chemical reaction.

Table salt, $NaCl_{(s)}$, can be formed by the reaction of sodium metal with chlorine gas:

$$2Na_{(s)} + Cl_{2(g)} \longrightarrow 2NaCl_{(s)}$$

A reaction mixture contains 45.98 g of sodium and 142. 0 g of chlorine. Calculate the mass of sodium chloride that is produced.

Step 1: Balance equation, List Given Values and Molar Masses.

Step 2x2: Convert Mass of a Given Substance to moles.

Step 3x2: Convert Amount of a Given Substance to Amount Required of a Given Substance using a MOLAR RATIO.

Step 5: Calculate the Amount of Product.

Step 6: Calculate the Mass of Product.

Percentage Yield

$$\text{percentage yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100\%$$

Term	Definition
	The amount of product produced in a chemical reaction.
	The amount of product that is actually produced in a chemical reaction.
	The amount of product expected from a balanced chemical equation.
	Actual vs. Theoretical Yield expressed as a percentage of Theoretical Yield.

The most common ore of Arsenic is $FeSAs_{(s)}$, can be heated to produce Arsenic, $As_{(s)}$:

$$FeSAs_{(s)} \longrightarrow FeS_{(s)} + As_{(s)}$$

When 250 kg of this ore was processed industrially, 95.3 kg of Arsenic was obtained. Calculate the percent yield of Arsenic.

Step 1: Balance Equation, List Values & Molar Masses.

Step 2: Convert Mass of Given Substance to Amount of Substance (n)

Step 3: Convert Amount of Substance to Amount of Required Sub.

Step 4: Convert Amount of Required Sub to Mass of Req. Sub.

Step 5: Calculate Percent Yield.