The McGraw-Hill Companies

Unit I - Lecture 3

Chemistry

The Molecular Nature of Matter and Change

Fifth Edition

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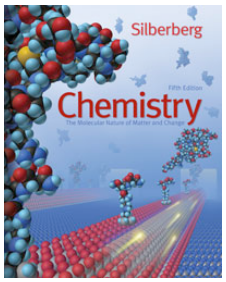


Chapter 2: The Components of Matter

2.1 Elements, Compounds, and Mixtures: An Atomic Overview

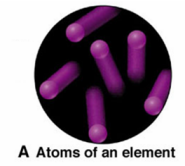
2.2 The Observations That Led to an Atomic View of Matter

2.3 Dalton's Atomic Theory

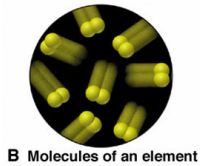
Definitions for Components of Matter

Element - the simplest type of substance with unique physical and chemical properties. *An element consists of only one type of atom.* It cannot be broken down into any simpler substances by physical or chemical means.

Molecule - a structure that consists of two or more atoms that are chemically bound together and thus behaves as an independent unit.



A Atoms of an element

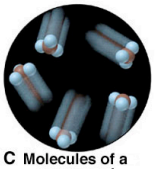


B Molecules of an element

Figure 2.1

Definitions for Components of Matter

Compound - a substance composed of two or more elements which are chemically combined.



C Molecules of a compound

Figure 2.1

D Mixture of two elements and a compound

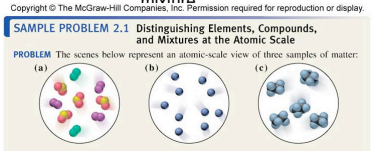
Mixture - a group of two or more elements and/o compounds that are physically intermingled.

Sodium Chloride

Property	Sodium	+ Chlorine	→ Sodium Chloride
			
Melting point	97.8°C	−101°C	801°C
Boiling point	881.4°C	−34°C	1413°C
Color	Silvery	Yellow-green	Colorless (white)
Density	0.97 g/cm^3	0.0032 g/cm^3	2.16 g/cm^3
Behavior in water	Reacts	Dissolves slightly	Dissolves freely

Sample Problem 2.1: Distinguishing Elements, Compounds, and Mixtures at the Atomic Scale

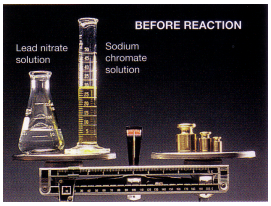
PROBLEM: Theses scenes represent an atomic-scale view of three samples of matter. Describe each sample as an element, compound, or mixture.

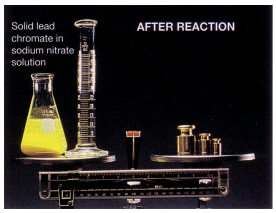


PLAN: Samples that contain one type of matter are either an element or a compound. An element contains only one type of particle and a compound contains two or more. Mixtures contain more than one type of matter.

SOLUTION: (a) mixture (b) element (c) compound

Figure 2.2 The law of mass conservation: mass remains constant during a chemical reaction.





Law of Mass Conservation

The total mass of substances does not change during a chemical reaction.

reactant 1 + reactant 2 ⟶ product

total mass = ***total mass***

calcium oxide + carbon dioxide ⟶ calcium carbonate

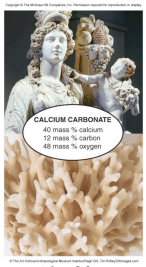
$CaO + CO_2 \longrightarrow CaCO_3$

56.08 g + 44.00 g ⟶ 100.08 g

Figure 2.3

Law of Definite (or Constant) Composition

No matter the source, a particular compound is composed of the same elements in the same parts (fractions) by mass.



Calcium carbonate

Analysis by Mass (grams/20.0 g)	Mass Fraction (parts/1.00 part)	Percent by Mass (parts/100 parts)
8.0 g calcium	0.40 calcium	40% calcium
2.4 g carbon	0.12 carbon	12% carbon
9.6 g oxygen	0.48 oxygen	48% oxygen
20.0 g	1.00 part by mass	100% by mass

Sample Problem 2.2 Calculating the Mass of an Element in a Compound

PROBLEM: Analysis of 84.2 g of the uranium containing compound pitchblende shows it is composed of 71.4 g of uranium, with oxygen as the only other element. How many grams of uranium can be obtained from 102 kg of pitchblende?

PLAN: The mass ratio of uranium/pitchblende is the same no matter the source. We can use the ratio to find the answer.

mass (kg) of pitchblende ⇩ mass (kg) of uranium ⇩⇩ mass (g) of uranium

SOLUTION:

$$\text{mass (kg) of uranium} = \text{mass (kg) pitchblende} \times \frac{\text{mass (kg) uranium in pitchblende}}{\text{mass (kg) pitchblende}}$$

$$= 102 \text{ kg pitchblende} \times \frac{71.4 \text{ kg uranium}}{84.2 \text{ kg pitchblende}} = 86.5 \text{ kg uranium}$$

$$86.5 \text{ kg uranium} \times \frac{1000 \text{ g}}{\text{kg}} = 8.65 \times 10^4 \text{ g uranium}$$

Law of Multiple Proportions

If elements A and B react to form two compounds, the different masses of B that combine with a fixed mass of A can be expressed as a ratio of small whole numbers.

Example: Carbon Oxides A & B

Carbon Oxide I : 57.1% oxygen and 42.9% carbon

Carbon Oxide II : 72.7% oxygen and 27.3% carbon

Assume that you have 100 g of each compound.

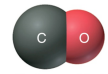
In 100 g of each compound: g O = 57.1 g for oxide I & 72.7 g for oxide II

g C = 42.9 g for oxide I & 27.3 g for oxide II

$$\frac{\text{g O}}{\text{g C}} = \frac{57.1}{42.9} = 1.33$$

$$\frac{\text{g O}}{\text{g C}} = \frac{72.7}{27.3} = 2.66$$

$$\frac{2.66 \text{ g O/g C in II}}{1.33 \text{ g O/g C in I}} = \frac{2}{1}$$



Carbon oxide I (carbon monoxide)

Carbon oxide II (carbon dioxide)

Dalton's Atomic Theory

The Postulates

1. All matter consists of atoms.

2. Atoms of one element *cannot* be converted into atoms of another element.

3. Atoms of an element are identical in mass and other properties and are different from atoms of any other element.

4. Compounds result from the chemical combination of a specific ratio of atoms of different elements.

Dalton's Atomic Theory

explains the mass laws

Mass conservation

Atoms cannot be created or destroyed *postulate 1*

or converted into other types of atoms. *postulate 2*

Since every atom has a fixed mass, *postulate 3*

during a chemical reaction atoms are combined differently, and therefore, there is no mass change overall.

Dalton's Atomic Theory

explains the mass laws

Definite composition

Atoms are combined in compounds in specific ratios *postulate 3*

and each atom has a specific mass. *postulate 4*

Each element has a fixed fraction of the total mass in a compound.

Dalton's Atomic Theory

explains the mass laws

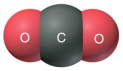
Multiple proportions

Atoms of an element have the same mass *postulate 3*

and atoms are indivisible *postulate 1*

When different numbers of atoms of elements combine, they must do so in ratios of small, whole numbers.

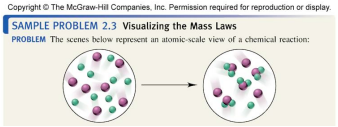
Carbon oxide I
(carbon monoxide)



Carbon oxide II
(carbon dioxide)

Sample Problem 2.3: Visualizing the Mass Laws

PROBLEM: Theses scenes represent an atomic-scale view of a chemical reaction. Which of the mass laws: mass conservation, definite composition, or multiple proportions is (are) illustrated?



PLAN: Mass conservation illustrated if number of each atom before and after reaction remains constant. Definite composition illustrated by formation of compounds that always have the same atom ratio. Different compounds made of same elements have small whole number ratios of those elements illustrates multiple proportions.

SOLUTION: Seven purple and nine green atoms in each circle, mass conserved. One compound formed has one purple and two green, definite composition. Law of multiple proportions does not apply.