TOPIC: 1.4 COMPOSITION OF MIXTURES

ENDURING UNDERSTANDING:

SPQ-2	Chemical formulas identify substances by their unique combination of atoms

LEARNING OBJECTIVE:

SPQ-2.B	Explain the quantitative relationship between the elemental composition by mass and the composition of substances in a mixture.

ESSENTIAL KNOWLEDGE:

SPQ-2.B.1	While pure substances contain molecules or formula units of a single type, mixtures contain molecules or formula units of two of more types, whose relative proportions can vary.
SPQ-2.B.2	Elemental analysis can be used to determine the relative numbers of atoms in a substance and to determine its purity.

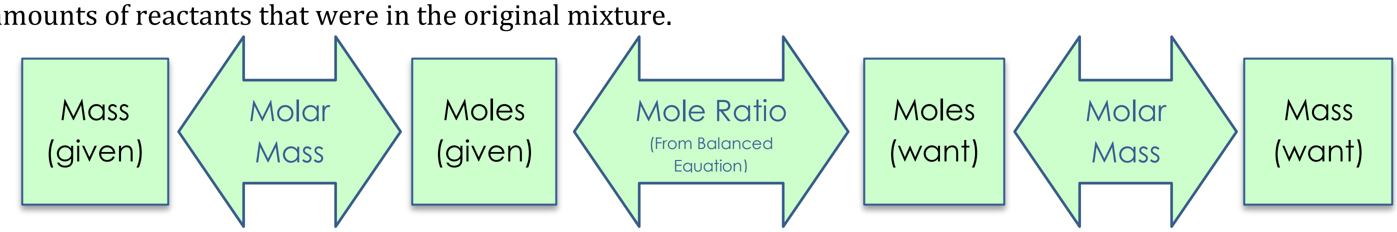
EQUATION(S):

	N/A

NOTES:

When two or more pure substances (elements and compounds) are combined they form a mixture. In mixtures the composition can vary. The mixture can be analyzed in order to determine the mass composition of each substance in that mixture.

You can use stoichiometry (mole ratios) to convert the masses of the products from the analysis to find the amounts of reactants that were in the original mixture.



The mass percentage of a substance in the mixture can be calculated:

$$\frac{\text{Mass of Substance}}{\text{Total Mass of Mixture}} \times 100 = \text{Mass Percentage}$$

Elemental Analysis to determine the composition of a mixture can be qualitative (identify the different elements present) or quantitative (identify the amounts of elements present.) Elemental analysis is a part of analytical chemistry.

Some examples of elemental analysis include:

- CHNX - Used by organic chemists to identify the mass fractions of carbon, hydrogen, nitrogen and other atoms such as halogens or sulfur. One form of this is combustion analysis. All of the carbon in a sample is converted into carbon dioxide, all of the hydrogen is converted into water, nitrogen is converted into nitrogen monoxide or nitrogen dioxide and sulfur (for example) is converted into sulfur dioxide.
- Spectroscopy
  - Optical – light is passed through a colored solution and the amount of light absorbed or transmitted is measured to determine the concentration of the solution (3.13 Beer-Lambert Law)
  - Mass – The charge to mass ratio is measured by atomizing then ionizing a sample, then accelerating the sample between charged plates and measuring the deflection of the sample. Greater deflection is found in smaller masses or larger charges. (1.2 Mass Spectroscopy)
  - Photoelectron – The energy to remove electrons from atoms is measured and can be translated into the electron configuration (arrangement) for an element. (1.7 Photoelectron Spectroscopy)

I DO:

Aluminum metal reacts with the air and forms a thin, corrosion resistant coating of aluminum oxide, Al_2O_3, according to the following unbalanced equation.

$$Al_{(s)} + O_{2\,(g)} \rightarrow Al_2O_{3\,(s)}$$

A sample of a mixture of aluminum and aluminum oxide weighing 120.91 grams were analyzed and found to contain 120.32 grams of aluminum.

a) Balance the equation provided.
b) What mass of oxygen was in the sample?
c) What mass of aluminum oxide was in the mixture?
d) What is the mass percent of aluminum oxide in the aluminum and aluminum oxide mixture?

a) $4\,Al + 3O_2 \rightarrow 2Al_2O_3$

b) $120.91\,g - 120.32\,g = 0.59\,g$ Oxygen

c) $0.59\,g\,O_2 \times \frac{1\,mol\,O_2}{32.0\,g\,O_2} \times \frac{2\,mol\,Al_2O_3}{3\,mol\,O_2} \times \frac{101.948\,g\,Al_2O_3}{1\,mol\,Al_2O_3} = 1.3\,g\,Al_2O_3$

d) $\frac{1.3\,g\,Al_2O_3}{120.91\,g\text{ Mixture}} \times 100 = 1.1\%$

WE DO:

The main component of egg shells is the compound calcium carbonate, $CaCO_3$. If you react egg shells with acetic acid, HCH_3COO, from vinegar the following reaction will take place.

$$CaCO_{3\,(s)} + 2\,HCH_3COO_{(aq)} \rightarrow H_2O_{(l)} + CO_{2\,(g)} + Ca(CH_3COO)_{2\,(aq)}$$

If 4.421 grams of carbon dioxide, CO_2, was produced from 10.57 grams of egg shells, what percentage of the mass of the egg shells was calcium carbonate?

SCAN ME

YOU DO:

1) A 15.0 gram sample of sodium hydrogen carbonate, $NaHCO_3$, was contaminated with an impurity. In order to determine the purity of the sample, it was heated to decompose the material according to the following reaction:

   $2NaHCO_3 \rightarrow Na_2CO_3 + H_2O + CO_2$

   If 6.35 grams of sodium carbonate, Na_2CO_3, were recovered, what percentage (by mass) of the sample was sodium hydrogen carbonate, $NaHCO_3$?

2) Devise a method to separate a mixture of sand, salt and iron filings.

3) A sample of brass weighing 1.203 grams was analyzed. Brass is an alloy composed of copper, Cu, and zinc, Zn. The zinc in the alloy was reacted with 35.123 grams of hydrochloric acid, HCl, in excess, according to the following balanced equation:

$$Zn_{(s)} + 2\ HCl_{(aq)} \rightarrow H_{2\,(g)} + ZnCl_{2\,(aq)}$$

After all of the zinc reacted the mass of the remaining solution weighed 36.309 grams.

a) What mass of hydrogen gas was produced?
b) What mass of zinc reacted?
c) What was the percentage of zinc (by mass) in the alloy?

4) A sample of sodium bromide, NaBr, has a mass percentage of sodium of 22.34%.

a) If the sample of sodium bromide were contaminated with sodium chloride, NaCl, would the mass percentage of Na in the sample be higher or lower than the pure sample? Justify your claim.
b) If the sample of sodium bromide were contaminated with sodium iodide, NaI, would the mass percentage of Na in the sample be higher or lower than the pure sample? Justify your claim.

5) A mixture consisting only of lithium chloride, LiCl, lithium carbonate, Li_2CO_3, and lithium nitrate, $LiNO_3$, was analyzed. The elemental analysis of the mixture revealed the following:

Element	% composition
Li	14.19 %
Cl	10.56 %
C	6.198 %
O	59.06%
N	10.01 %

Calculate the mass percentage of each compound in the mixture.