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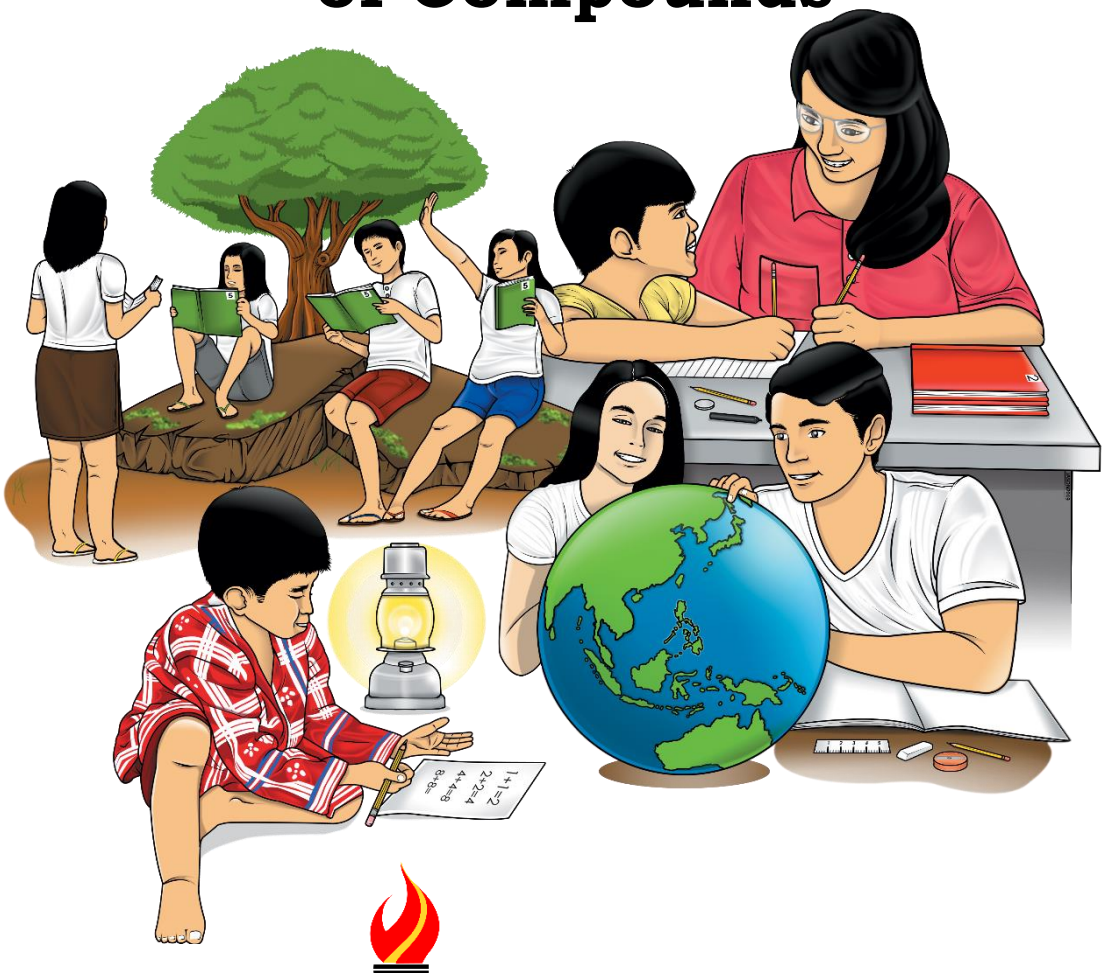
Science

Quarter 2 - Module 9
Percentage Composition of Compounds



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Introductory Message

This Self-Learning Module (SLM) is prepared so that you, our dear learners, can continue your studies and learn while at home. Activities, questions, directions, exercises, and discussions are carefully stated for you to understand each lesson.

Each SLM is composed of different parts. Each part shall guide you step-by-step as you discover and understand the lesson prepared for you.

Pre-tests are provided to measure your prior knowledge on lessons in each SLM. This will tell you if you need to proceed on completing this module or if you need to ask your facilitator or your teacher's assistance for better understanding of the lesson. At the end of each module, you need to answer the post-test to self-check your learning. Answer keys are provided for each activity and test. We trust that you will be honest in using these.

In addition to the material in the main text, Notes to the Teacher are also provided to our facilitators and parents for strategies and reminders on how they can best help you on your home-based learning.

Please use this module with care. Do not put unnecessary marks on any part of this SLM. Use a separate sheet of paper in answering the exercises and tests. And read the instructions carefully before performing each task.

If you have any questions in using this SLM or any difficulty in answering the tasks in this module, do not hesitate to consult your teacher or facilitator.

Thank you.

What I Need to Know

After going through the module, you are expected to:

1. List down the elements in a given compound.

2. Determine the percentage composition given the chemical formula of a compound.
3. Determine the percentage composition of a compound given its mass.

4. Analyze the percentage composition of different brands of two food products.

What I Know

Pre-test. Direction: Read the following questions carefully and answer the following:

A. List down the elements that are present in the following compounds:

1. Water, H_2O: _____

2. Sodium Hypochlorite, NaOCl: _____

3. Sugar, $C_{12}H_{22}O_{11}$: _____

4. Eggshell, $CaCO_3$: _____

5. Baking Soda, $NaHCO_3$: _____

B. Read the text carefully and answer the questions in the statement that follows.

Sodium chloride (NaCl), or commonly known as the Table Salt is a compound that is used in food preparation as a food flavouring and as a preservative. Each element present in the table salt contains the following atomic masses: Na=22.99g and Cl = 35.45g.

6. How many grams is in 1 mole of sodium in sodium chloride?

a. 35.45 g b. 22.99 g c. 22.00 g d. 1.01 g

7. How many grams is in 1 mole of chlorine in sodium chloride?

   a. 35.45 g b. 22.00 g c. 22.99 g d. 1.01 g

8. What is the total mass of sodium chloride?

   a. 22.99 g b. 35.45 g c. 58.44 g d. 81.43 g

9. What is the percentage composition of sodium in sodium chloride?

   a. 22.99% b. 35.45% c. 39.34% d. 60.66%

10. What is the percentage composition of chlorine in sodium chloride?

    a. 22.29% b. 35.45% c. 39.34% d. 60.66%

C. Water (H_2O) as a compound is the most essential commodity for human consumption. Complete the given table below and calculate the percentage composition of water. (Atomic masses: H= 1.01 g, O=16.00g)

Name of Compound	Chemical Formula	Symbol of Elements	Atomic Mass (g)	Number of atoms (Refer to the Chemical formula)	% Composition
Water	11. ___	H O	H = 1.01 O = 16.00	12. _ atoms of H 13._ atoms of O	14. H = __ 15. O = __

Lesson 1

Percentage Composition of a Compound: *What is it?*

What's In

In the earlier lessons you have learned about calculating the molar mass, as well as the connection between molar mass, number of moles, and number of particles in a mole of a substance. You have also learned that molar mass is the mass in grams of one mole of a substance expressed as g/mol. In your grade 7 lessons, you also knew about compounds. Compounds, as you might recall is a substance made up of two or more elements.

Water (H_2O) is a very common compound. It has the element Hydrogen and Oxygen. It has a molar mass of 18 g/mol and consist of 2 moles of Hydrogen atoms and 1 mole of oxygen atom.

In this lesson, you will apply your knowledge about compounds and the mole concept in order to determine the percentage composition of a substance, in particular compounds.

What's New

It's picture analysis time. What can you tell about the image below?

The picture to the right tells you about a test score. What else can you see in this image?

This image shows the score of a student on a 20-item quiz. The student gets a score of 18 over 20 (18/20) or 90%. It means that the student gets 18 correct answers and 2 wrong answers.

The 90% is called the percentage score. If you want to get your percentage score in a test, you simply divide your score over the total test item and multiply it by 100. So, in this example, we have 18/20 x 100 = 90%.

The table below, shows the percentage score of the student.

Number of correct	Total Number of Items	(No. of correct answers/ total number of	% Score of Correct answer
18	**20**	**(18/20) x 100**	**90%**

How much percent did the student answered wrong in the test? Try this one.

Number of wrong answers	Total Number of Items	(No. of wrong answers/ total number of	% Wrong answer

Now, why do we need to multiply the percentage score by 100? Because **percentage would also mean an amount in hundred or by a hundred**. It is often represented by the percent sign (%). In this lesson, you will know about percentage composition. Similarly, the concept is likely the same as getting a percentage in a test score like the example above. So, what is percentage composition? Let's go deeper in the next section "What is it?"

What Is It

A compound, as you might recall from your past lessons, is represented by a chemical formula that shows the number of atoms of each element in the compound. It contains the symbols of the atoms of the elements present as well as the number of each element present in the form of subscripts**.**

The percentage composition of any given compound is identified as the fraction of the amount of each element on the total amount of individual elements present in the compound multiplied by 100. It is simply an expression of its composition in terms of all the elements present. Knowing the percent composition in a compound is useful in determining the empirical formula of a chemical substance which will be discussed in your higher years. The percentage composition of a compound can be computed given its chemical formula or given its mass data.

A. Percentage Composition from a Chemical Formula of a compound

The percent composition of a compound can be determined from the chemical formula of a compound. The subscripts in the formula are first used to calculate the mass of each element in one mole of a compound. It will then be divided by the molar mass of the compound, and the answer is multiplied by 100. The formula is given below.

$$\% \text{ composition} = \frac{\text{Mass of element in 1 mole}}{\text{Molar mass of a compound}} \times 100$$

From the given formula, you can determine the percentage composition by knowing the following data first:

1. The elements present in the compounds
2. Atomic mass of each elements
3. Number of atoms of each element
4. The Molar mass

Let's try this one!

Sample Problem 1. Muriatic acid, also known as Hydrochloric acid (HCl) is used as a cleaning agent to get rid of tough stains and molds in the house. Calculate the percentage composition of muriatic acid? (Atomic masses: H=1.01g, Cl=35.45 g,from the Periodic Table)

Name of Compound	Chemical Formula	Symbol of Elements	Atomic Mass	Number of atoms (Refer to the Chemical formula)	% Composition
Hydrochloric Acid	HCl	H Cl	H = 1.01 g Cl = 35.45 g	1 atom of H 1 atom of Cl	H= ? Cl =?

From this table, you list down the known and unknown quantities.
Step 1: List the known and unknown quantities.

Known:

- mass of H in 1 mol H=1.01 g (where, 1 mole H=1.01g)
- mass of Cl in 1 mol HCl= 35.45 g (where; 1 mole Cl=35.45g)
- Molar mass of HCl=36.46 g/mol

Unknown:

- Percent H = ? %
- Percent Cl =? %

Calculate the percentage composition of each element by dividing the mass of each element by the molar mass of the compound and multiplying by 100%.

Step 2: Calculate.

$$\% H = \frac{1.01 \text{ g H}}{36.46 \text{ g}} \times 100\ \% = 2.77\ \% H$$

$$\% Cl = \frac{35.45 \text{ g Cl}}{36.46 \text{ g}} \times 100\ \% = 97.23\ \% Cl$$

Step 3: Review your result. It should total up to 100%.

% H = 2.77 % H

% Cl = 97.23 % Cl

Total = 100.00 %

Therefore, HCl has 2.77% Hydrogen and 97.23% Chlorine.

B. Percent Composition from Mass Data

Percentage composition can be calculated given its masses from each of the element present in a compound. The sample problem below shows the calculation of the percentage composition of a compound based on mass data.

Sample Problem 2.

A certain newly synthesized compound is known to contain elements zinc and oxygen. When 30.00 grams of sample is decomposed; 24.12 g zinc remains. Determine the percent composition of the compound?

Step 1: List the known and unknown quantities.

Known:

- mass of compound = 30.00 g
- mass of zinc =24.12 g

Unknown:

- Percent Zn =? %
- Percent O =? %

Hint: Subtract to find the mass of oxygen in the compound. Divide each element's mass by the total mass of the compound to find the percent by mass.

Step 2: Calculate

Mass of oxygen = 30.00 g – 24.12 g = 5.88 g O

$$\% \text{ Zn} = \frac{24.12 \text{ g Zn}}{30.00 \text{ g}} \times 100\ \% = 80.40\ \% \text{ Zn}$$

$$\% \text{ O} = \frac{5.88 \text{ g O}}{30.00 \text{ g}} \times 100\ \% = 19.60\ \% \text{ O}$$

Step 3: Review your result. It should total up to 100%.

% Zn = 80.40 % Zn

% O = 19.60 % O
100.00 %

The calculations sound reasonable because this adds up to 100%. And you can see in the result that by mass, the compound is mostly zinc with 80.40% composition.

What's More

Exercises

Read each worded problem carefully and determine the percentage composition of the compound.

1. Sucrose ($C_{12}H_{22}O_{11}$) or known as the table sugar has a molar mass of 342.1 g/mol.

   What is the percentage composition of each element in this compound? (Atomic masses: C=12.01 g; H=1.01g; O=16.00g from the Periodic Table)

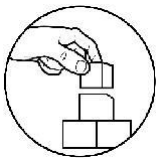
Name of Compound	Chemical Formula	Symbol of Elements	Atomic Mass	Number of atoms (Refer to the chemical formula)	Molar Mass	% Composition
Sucrose (Table Sugar)	$C_{12}H_{22}O_{11}$	C H O	C = 12.01 g H = 1.01 g O= 16.00 g	12 atoms of C 22 atoms of H 11 atoms of O	342.1 g/mol	C =? H =? O =?

Step 1: List the known and unknown quantities.
Step 2: Calculate
Step 3: Study your result. It should total up to 100%.

2. A sample of a compound containing carbon and oxygen have a mass of 132 g.

   Experimental procedures showed that 36 g of this sample was carbon and the remaining 64g was oxygen. What is the percentage composition of the compound?

   Step 1: List the known and unknown quantities.
   Step 2: Calculate
   Step 3: Study your result. It should total up to 100%.



What Have I Learned

Activity 1: What Am I Consisted Of?

Objective:

- Determine the percentage composition of some compounds that could be found in your homes.
- Identify the components of the compounds
- Cite the significance of these compounds.

Materials:

Periodic table of elements, calculator

Procedure:

A. Read the following substances commonly found at home. Be familiar with its uses and composition.

1. Water (H_2O) is the most essential commodity for human consumption. Living things on earth could not survive without water. (Atomic masses: H=1.01g; O=16.00g from the Periodic Table)
2. An *eggshell* is the hard, outer covering of an egg. It consists mostly of calcium carbonate ($CaCO_3$), which is a common form of calcium. (Atomic masses: Ca=40.08g; C=12.01; O=16.00g from the Periodic Table)
3. Phosphoric acid (H_3PO_4) is a compound used in detergents, fertilizers, toothpastes and flavouring in carbonated beverages. (Atomic masses: H=1.01g; P= 30.97g; O=16.00g from the Periodic Table)

B. Fill-In the table below. Then, calculate the percentage composition of each element in the compounds.

Name of Compound	Chemical Formula	Symbol of Elements	Atomic Mass	Number of atoms	Molar Mass	% Composition
Water			H = 1.01 g O = 16.00 g			H =? O =?
Calcium Carbonate	$CaCO_3$			1 atom of Ca 1 atom of C 3 atoms of O		Ca =?
Phosphoric Acid		H P O			98.00 g/mol	

Guide Questions:

Q1. What are the elements present in these compounds: (a) *Water, (b) Calcium Carbonate and (c) phosphoric acid?*

Q2. What is the percentage composition of the elements of each compound?

Q3: Other than what was mentioned above, what are the other uses of the (a) Water, (b) Calcium carbonate, and (c) Phosphoric acid?

What I Can Do

Activity No. 2: What is your Snack's Nutritional Composition?

Objective:

1. Determine the composition of a chocolate cracker on a percent by mass basis.
2. Determine the composition of a fish cracker on a percent by mass basis.
3. Analyze the protein, fats and carbohydrates contents of several food snacks.

Materials:

Nutrition facts in the label of a *chocolate cracker and fish cracker*

Procedure:

1. Foods that you buy typically at the store or at the school canteen have nutritional information provided on the label. Study the label of certain snack crackers shown below.
2. List down the nutrition facts that are present in these snack crackers. Note the one that has been encircled for you.

Figure A. Chocolate Cracker

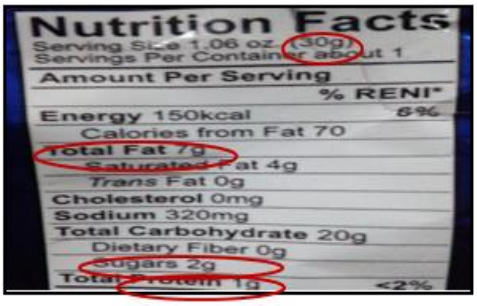


Figure B. Fish Cracker

Guide Questions:

For questions 1 to 4. Provide your answer on the table below

Q1. What information can you find in the nutrition facts given in these snack crackers?

Q2. How much is one serving size in terms of grams?

Q3. The label also gives the masses of various types of compounds that are present in each serving. How many grams of proteins, fats and sugar are there in one serving?

Snack Cracker	Nutrition facts	Mass of each nutrition facts	Serving size in grams	% Composition
a. Chocolate Cracker		___ g of fats ___ g of protein ___ g of sugar		__ % of fats __ % of protein __ % of sugar
b. Fish Cracker		___ g of fats ___ g of protein ___ g of sugar		__ % of fats __ % of protein __ % of sugar

Q4. Determine the composition of the snack crackers on a percent by mass basis by calculating the fraction of fats, protein and sugar in one serving of size of cracker and converting to percent values. Use the following formula as your guide:

$$\%\ \text{total fats} = \frac{\text{mass of total fats}}{\text{serving size (g)}} \times 100\ \% = \_\_\_\_\_\ \%\ \text{fats}$$

$$\%\ \text{protein} = \frac{\text{mass of protein}}{\text{serving size (g)}} \times 100\ \% = \_\_\_\_\_\ \%\text{protein}$$

$$\%\ \text{sugar} = \frac{\text{mass of sugar}}{\text{serving size (g)}} \times 100\ \% = \_\_\_\_\_\ \%\ \text{sugar}$$

Q5. Which of the two snack crackers has the most fats, protein and sugar?

Which do you think has more nutritional value?

Summary

The percentage composition of a compound is shown as the fraction of the amount of each element on the total amount of individual elements given in the compound multiplied by 100. The formula is given below.

$$\% \text{ composition} = \frac{\text{Mass of element in 1 mole}}{\text{Molar mass of a compound}} \times 100\ \%$$

From the given formula, it shows that percentage composition is simply an expression of its composition in terms of all the elements present. Hence, to get the percentage composition of a certain compound, simply know first the elements present in the compound, the atomic masses of each element, number of atoms of each element and the molar mass. There are two processes in getting percentage composition. It is either by calculating given the chemical formula of the compound or given the mass data of the compound.

Assessment: (Post-Test)

Post-test. Direction: Read and answer the following questions carefully.

A. List down the elements that are present in the following substances:

1. Water, H_2O: _____
2. Sodium Hypochlorite, NaClO: _____
3. Sugar, $C_{12}H_{22}O_{11}$: _____
4. Eggshell, $CaCO_3$: _____
5. Baking Soda, $NaHCO_3$: _____

B. Read the text carefully and answer the questions in the statement that follows.

> Sodium chloride (NaCl), or commonly known as the table salt, is a compound that is used in food preparation as a food flavoring and as preservative. The molar mass of the elements are given: Na=22.99g/mol and Cl = 35.45g/mol

6. How many grams is in 1 mole of sodium in sodium chloride?

a. 35.45 g b. 22.99 g c. 22.00 g d. 1.01 g

7. How many grams is in 1 mole of chlorine in sodium chloride?
   a. 35.45 g b. 22.00 g c. 22.99 g d. 1.01 g
8. What is the total mass of sodium chloride?
   a. 22.99 g b. 35.45 g c. 58.44 g d. 81.43 g
9. What is the percentage composition of sodium in sodium chloride?
   a. 22.99% b. 35.45% c. 39.34% d. 60.66%
10. What is the percentage composition of chlorine in sodium chloride?
   a. 22.29% b. 35.45% c. 39.34% d. 60.66%

C. Water (H_2O) as a compound is the most essential commodity for human consumption. Complete the given table below and calculate the percentage composition of water. (Atomic masses: H= 1.01 g, O=16.00g)

Name of Compound	Chemical Formula	Symbol of Elements	Atomic Mass (g)	Number of atoms (Refer to the Chemical formula)	% Composition
Water	11. ___	H O	H = 1.01 O = 16.00	12. _ atoms of H 13._ atoms of O	14. H = __ 15. O = __

Additional Activity

Monosodium glutamate (MSG) or commonly known as "Vetsin" has a chemical formula $C_5H_8NO_4Na$. It is commonly added to food to enhance its flavor. The table below shows the percentage composition of the following elements present in the compound: Carbon (C), Hydrogen (H), Nitrogen (N), and Oxygen (O). Find the percentage composition of Sodium (Na)?

Name of Compound	**Chemical Formula**	**Elements Present in the Compound**	**% Composition of Each Element**
Monosodium Glutamate	$C_5H_8NO_4Na$	Carbon (C)	C = 35.51%
		Hydrogen (H)	H = 4.77%
		Nitrogen (N)	N = 8.28%
		Oxygen (O)	O = 37.84%
		Sodium (Na)	Na = _____

Hint: The percentage composition of all elements present in the compound should total up to 100%.

Answer Key

For practice exercises:

1.Table sugar ($C_{12}H_{22}O_{11}$) is 42.11% carbon, 6.48% hydrogen, and 51.41% oxygen

2.The compound contains 27.27% carbon and 72.73% oxygen

For activity 1:

1. Water is 11.19% hydrogen and 88.81% oxygen.
2. The percentage composition of Carbon in Calcium Carbonate ($CaCO_3$) is 40.04%
3. Phosphoric acid (H_3PO_4)is 3.09% hydrogen, 31.60% phosphorus and 65.31% oxygen

For Activity 2:

1. It contains protein, fats and sugar.
2. Each serving contains 30 grams.
3. (a) Chocolate cracker: 2 grams of protein, 6 grams of total fats, &11 grams of sugar
   (b) Fish cracker: 1 gram of protein, 7 grams of total fats, & 2 grams of sugar
4. (a) Chocolate cracker: 6.67% protein, 20.00% fat, & 36.67%sugar
   (b) Fish cracker: 3.33% protein, 23.33% fat, & 6.67% sugar
5. The chocolate cracker has more protein and sugar content than the fish cracker. But both snack crackers may provide energy to the body because of its nutritional content.

For pre-test and post

1. *Water, H_2O: Hydrogen, Oxygen*
2. *Sodium Hypochlorite, NaOCl: Sodium, Oxygen and Chlorine*
3. *Sugar, $C_{12}H_{22}O_{11}$: Carbon, Hydrogen and Oxygen*
4. *Eggshell, $CaCO_3$: Calcium, Carbon and Oxygen*
5. *Baking Soda, $NaHCO_3$: Sodium, Hydrogen, Carbon and Oxygen*
6. *b. 22.99 g*
7. *a. 35.45 g*
8. *c. 58.44 g*
9. *c. 39.34 %*
10. *d. 60.66 %*
11. *H_2O*
12. *2 atoms of Hydrogen*
13. *1 atom of Oxygen*
14. *11.21% Hydrogen*
15. *88.79% Oxygen*

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