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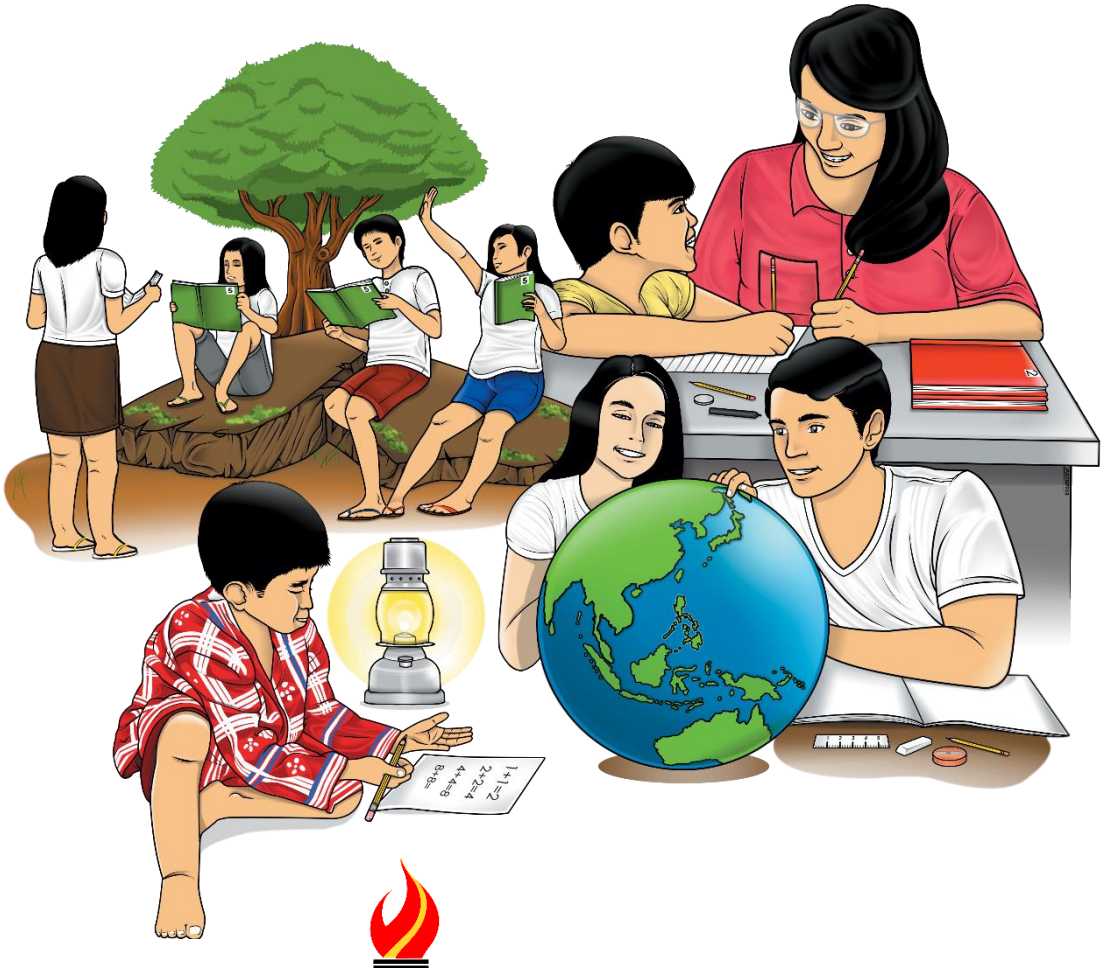
DEPARTMENT OF EDUCATION

Science
Quarter 2- Matter
Module 7: The Mole Concept



ALTERNATIVE DELIVERY MODE
ADM

Science – Grade 9
Alternative Delivery Mode
Quarter 2: Matter - Module 7: The Mole Concept
First Edition, 2020

Published by the Department of Education
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Undersecretary: Diosdado M. San Antonio

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Printed in the Philippines by _____

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Science
Quarter 2- Matter
Module 7: The Mole Concept

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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

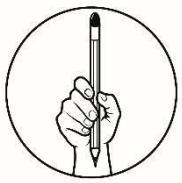
This module is designed and written with you in mind. It is here to help you master The Mole Concept. The scope of this module permits it to be used in many different learning situations. The language used recognizes the diverse vocabulary level of students. The lessons are arranged to follow the standard sequence of the course, but the order in which you read them can be changed to correspond with the textbook you are now using.

The module focuses on achieving this learning competency:

Use the mole concept to express mass of substances. (S9MT-IIi-19)

After going through this module, you are expected to:

- differentiate molecular unit from formula unit and compute for the molecular mass;
- define mole and calculate for the number of moles of given compounds;
- compute for the number of particles given the mass or number of moles; and,
- convert number of moles, mass, and number of particles from one unknown to another.



What I Know

Choose the letter of the best answer. Write your answer on a separate sheet of paper.

1. Which is the correct formula unit for sodium chloride?
   A. NaCl
   B. Na_2Cl
   C. Na_3Cl_2
   D. Na_2Cl_5

2. Caffeine is a natural compound commonly found in coffee, tea, chocolate, and softdrinks. What is the molar mass of caffeine ($C_8H_{10}N_4O_2$)?
   A. 171.1 g/mol
   B. 189.4 g/mol
   C. 194.2 g/mol
   D. 199.8 g/mol

3. The pain reliever mefenamic acid contains an active ingredient called Ibuprofen $C_{13}H_{18}O_2$. What is the molecular mass for this compound?
   A. 200.1 g/mol
   B. 206.3 g/mol
   C. 222.3 g/mol
   D. 240.54 g/mol

4. Amedeo Avogadro is an Italian scientist who used a constant number to represent the mole of a substance. Which of these represents the number of units in one mole of any substance?
   A. 3.01×10^{23}
   B. 3.01×10^{24}
   C. 6.02×10^{23}
   D. 6.02×10^{24}

5. Which represents a mole?
   A. 6 g of NaCl
   B. 3.01×10^{23} CH_4 molecules
   C. 6.02×10^{23} F atoms
   D. 25 g graphite, C-atom

6. How is molar mass of a substance calculated?
   A. Atomic mass of an element minus the number of atoms as indicated by chemical formula.
   B. Number of atoms as indicated by chemical formula divided by atomic weight.
   C. Atomic mass of an element multiplied by the number of each atom of each element as indicated by chemical formula then add all the products of all the elements.
   D. Number of atoms as indicated by chemical formula divided by atomic mass of an element.

7. If one mole of Aluminum weighs 26.98 grams, what is the mass in grams of 4.30 moles of Aluminum?
   A. 22.68 g Al B. 6.27 g Al C. 27.28 g Al D. 116 g Al

8. Which is the correct way of converting moles to mass?
   A. number of moles multiplied by molar mass
   B. number of moles divided by the molar mass
   C. number of moles divided by the Avogadro's number
   D. number of moles multiplied by Avogadro's number

9. How many moles are contained in 34g of NH_3?
   A. 1 mol B. 2 mol C. 17 mol D. 34 mol

10. What is the mass of 4.39 mol Na?
   A. 191 g B. 252 g C. 120 g D. 101 g

Lesson 1 The Mole Concept

In this module you will be able to: differentiate molecular unit from formula unit and compute for the molecular mass; define mole and calculate for the number of moles of given compounds; compute for the number of particles given the mass or number of moles; and, convert number of moles, mass, and number of particles from one unknown to another.

For example, a game show requires the contestants to guess the number of mongo seeds in a container. The player who guesses closest amount to the actual number of seeds will win the grand prize. How would they estimate the number of seeds without counting it one by one?

One way to get the easiest estimation is to count 10 seed or more, then weigh them and find their ratio. This is similar in counting the number of atoms in a substance, but it is more difficult because atoms cannot be counted nor weighed individually.

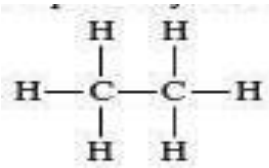
In this module, you will learn how to express the mass of substance using the basic concept of mole.

Here are some key questions for you to ponder after finishing this module:

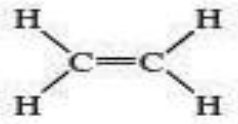
1. What is a mole?
2. What is the difference between molecular and formula unit?
3. What is the relationship of the mole to mass and number of particles of a compound or element?
4. How to calculate the number of particles (atoms, molecules, ions) from moles or vice versa?
5. What are the steps in converting number of moles to mass or vice versa?

What's In

In the previous module, you have learned the different kinds of hydrocarbons and their uses. Look at the structural diagram of hydrocarbons below and answer the following questions.



(a)



(b)

(c)

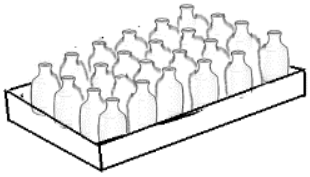
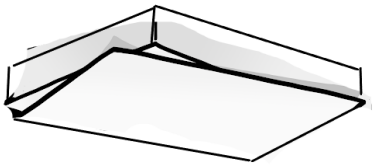
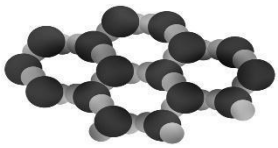
Guide Questions:

1. Which of these sets of hydrocarbons is alkane?
2. Which of these are alkene and alkynes?
3. How will you describe the bond between b and c?
4. What elements are mostly present in all the three given compounds?

What's New

The counting units are often used to easily represent the number of items. It is more convenient to represent this as collective counting words than counting them individually. Atoms are incredibly small. It is impossible to count the number of atoms or molecules to get their mass. Using counting units, we can easily represent the number of atoms. Complete the needed information in the third column.

Items	Counting Units	Number of Pieces
Slippers 	Pair	2
Eggs 	Dozen	

Bottles 	Case	
 Papers	Ream	
 Atoms, Molecules, Ions	Mole	

What is It

Molecular and Formula Mass

Let us differentiate molecular mass from formula mass. The formula mass and molecular mass are two values that express the size of a molecule. The formula mass of a molecule is the sum average of the atomic weights of the atoms in its empirical formula.

However, the molecular mass of a molecule is its average mass as calculated by adding the atomic weights of the atoms in the molecular formula.

The table shows the difference between formula and molecular mass:

Formula mass	**Molecular mass**
Use amu (atomic mass unit) as units.	Use g/mol (gram per mole) as units.
Mass of molecules may not be exact.	Always give the exact mass of a mole of molecules
Calculated through empirical formula	Calculated through molecular formula
Sum of the masses of atoms present in the empirical formula.	Mass of a mole of a given molecule.
Used for ionic compounds	Used for covalent bond compounds

Let us analyze the given samples using the following steps to calculate molecular mass of a substance.

Steps in Calculating Molecular Mass

1st step: Determine the number of atoms of the elements present in the molecule.

2nd step: Find the atomic mass of each atom using the periodic table of elements. Multiply the atomic mass to the number of atoms of the elements present in the molecule.

3rd step: Get the sum of all the product.

Sample 1: Mefenamic acid consist of $C_{13}H_{18}O_2$, a common compound that is mostly used in pain medication. What is the molecular mass for this compound?

Element	Quantity		Average atomic mass		Subtotal (amu)
C	13	X	12.01	=	156.13
H	18	X	1.01	=	18.18
O	2	X	16.00	=	32.00
			Molecular Mass		206.31

The molecular mass of mefenamic acid ($C_{13}H_{18}O_2$) is **206.31 amu**

Steps in Calculating Formula Mass

1st step: Determine the number of atoms of the elements present in the molecule.

2nd step: Find the atomic mass of each atom using the periodic table of elements. Multiply the atomic mass to the number of atoms of the elements present in the molecule.

3rd step: Get the sum of all the product.

Sample 2: Compute the formula mass of limewater, $Ca(OH)_2$

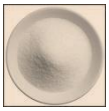
Element	Quantity		Average atomic mass		Subtotal (amu)
Ca	1	X	40.08	=	40.08
H	2	X	1.01	=	2.02
O	2	X	16.00	=	32.00
			Formula Mass		74.10

The formula mass of limewater, $Ca(OH)_2$ **74.10 amu**.

What is Mole?

We use counting units to easily represent the quantity of materials. Just as we denote 1 dozen for 12 eggs, it can be 1 dozen for 12 bananas or 12 candies. Similarly, a mole is used to count entities on a microscopic level like atoms, molecules, ions, particles etc.

In Chemistry, mole (mol) is simply defined as the quantity of a substance which contains the same number of particles. Look at the illustration below to understand how the mole expresses quantity and unit based on number.



1 mole of table salt (NaCl)

= 6.02 x 10^{23} NaCl ion pair

1 mole of Gold (Au)

= 6.02 x 10^{23} Au atoms

1 mole of sugar ($C_{12}H_{22}O_{11}$)

= 6.02 x 10^{23} sugar ($C_{12}H_{22}O_{11}$)

1 mole of water (H_2O)

= 6.02 x 10^{23} H_2O molecules

In counting the number of atoms, we use a constant number called Avogadro's number which is equivalent to a MOLE. Understanding the basic concept of a mole is the key in relating mass, mole, and number of particles in elements, compounds and chemical reactions. This chemical calculation used in chemistry is known as stoichiometry.

One mole is the amount of substance that contains as many particles as there are present in 12 grams of Carbon-12 atom. The actual number of atoms in 12 g of Carbon-12 isotope is equal to 6.02x10^{23} particles called Avogadro's number, in honor of the Italian scientist Amadeo Avogadro.

1 mole $_{12}C$ = 12.00g $_{12}C$ = 6.02 x 10^{23} $_{12}C$ atoms

Calculating Number of Mole Given the Mass or Vice Versa

Operationally, the number of moles is determined using the formula.

$$Mole = \frac{Mass\ (in\ g)}{Formula\ or\ molecular\ mass}$$

Let us calculate the number of moles of oxygen (O_2) in 24.0 g of O_2. From the definition of a mole, we know that 1 mole of O_2 = 32.0 g.

Solution:

$$Mole = 24.0 \cancel{g\ O_2} \frac{1\ mole\ O_2}{32.0 \cancel{g\ O_2}}$$

Mole = 0.75 mole of O_2

Mole-Mass Relationship and Calculation

Chemists generally use the mole as the unit for the numbers of atoms or molecules of a substance. In the previous discussion, molecular mass of any element can be determined by finding the atomic weight of the element on the periodic table.

By recognizing the relationship between the molecular mass, moles, and particles, scientists can use dimensional analyses to easily convert mass, number of moles of atoms or vice versa.

For simple mole to mass conversion, here is the general pattern:

Cases	General Pattern
Case 1: No. of moles is given; mass is unknown	Mass = given number of moles x molar mass $Mass\ =\ given\ number\ of\ moles\ x\ \frac{g}{mol}$
Case 2: Mass is given; no. of moles is unknown	Number of moles = given mass X molar mass $Number\ of\ moles\ =\ given\ mass\ x\ \frac{mol}{g}$

Case 1: No. of moles is given; mass is unknown

Problem: What is the mass in grams of 2 moles of magnesium?

Computation Process:

Step 1. Identify the given.

Given: 2 moles of magnesium
1 mole of Mg = 24 g Mg

Unknown: mass in grams of Mg
1 mole of Mg = 24 g Mg

Step 2. Identity the case on the table above and use the formula.

Case 1: $Mass\ =\ given\ number\ of\ moles\ x\ \frac{g}{mol}$

Step 3. Substitute the value in the equation.

$$Mass = 2\ \cancel{moles\ of\ Mg}\ x\frac{24\ g\ Mg}{1\ \cancel{mol\ Mg}} = 48\ g\ of\ Mg$$

Case 2: Mass is given; no. of moles is unknown

Problem: What is the number of moles of 36 g of water (H_2O)?

Computation Process:

Step 1. Identify the given and unknown.

Given: 36 g of H_2O
Unknown: number of moles and molar mass of water (H_2O)

Step 2. Determine the molar mass of a compound

H =	1 g	x	2	=	2 g
O =	16 g	x	1	=	16 g

The molar mass of water (H_2O) is **18 g/mol**

Step 3. Substitute the values in the equation, in this we will use the formula in case no. 2.

$$Number\ of\ moles = 36\ \cancel{g\ of\ H_2O}\ x\frac{1\ mol\ of\ H_2O}{18\ \cancel{g\ of\ H_2O}} = 2\ mol\ of\ H_2O$$

The unit for the number of mole is expressed as mole or *mol*.

Mole-Number of Particles Relationship

From our previous discussion, you have already learned that is the mole can be used to relate masses of substance to the quantity of atoms therein. This is an easy way of determining how much of one substance can react with a given amount of another substance.

From moles of a substance, you can also find the number of atoms in a substance and vice versa.

In this part, let us find out how to convert moles and the number of atoms in each substance using Avogadro's number.

We know that the number of particles present in 12 g of carbon is $6.02x10^{23}$. This is known as Avogadro's number. The number of particles (atoms, molecules, ions) is equal to Avogadro's number 6.02×10^{23} in honor of the scientist **Amedeo Avogadro**.

Here is the formula that is used in determining the number of particles of a compound:

No. of particles = n X N

Where:

n = number of moles

N = Avogadro's number which has a constant value of 6.02×10^{23}

Let us try to analyze the sample problem.

Problem: Carbon dioxide is the by-product of the respiration of humans and animals. It is used by plants to perform photosynthesis. If a human released 3 moles of CO_2 in a second, how many molecules of CO_2 are there?

Computation Process:

Step 1: Identify the given and unknown.

Given: 3 moles of CO_2
Unknown: No of particles (molecules)

Step 2: Substitute the given in the equation.

No. of particles = 3 moles x 6.02 $x10^{23}$ CO_2 molecules

= 18.06 x 10^{23} CO_2 molecules

= 1.806 x 10^{24} CO_2 molecules

What's More

Activity 1. Molecular Mass

Compute the molecular mass of the given compounds. Write your answer on a separate sheet of paper.

1. Copper (II) Sulfate ($CuSO_4$)

Element	Quantity		Average atomic mass		Subtotal
Cu		X		=	
S		X		=	
O		X		=	
			Molecular Mass		

2. Potassium Permanganate ($KMnO_4$)

Element	Quantity		Average atomic mass		Subtotal
K		X		=	
Mn		X		=	
O		X		=	
			Molecular Mass		

3. Lead (II) Nitrate $Pb(NO_3)_2$

Element	Quantity		Average atomic mass		Subtotal
Pb		X		=	
N		X		=	
O		X		=	
			Molecular Mass		

4. Ammonium Sulfate $(NH_4)_2SO_4$

Element	Quantity		Average atomic mass		Subtotal
N		X		=	
H		X		=	
S		X		=	
O		X		=	
			Molecular Mass		

Activity 2. What's the code?

To find the answer to the question, look at the solution section below. Write the answer to the problems on the line (indicate the letter that correspond to each answer). See the given examples. You may write your answer on a separate sheet of paper.

Solution Section:

(A) 0.02 mol	(E) 8.02 g	(I) 4.80 g
(B) 2.03 mol	(F) 9.03 g	(J) 921.95 g
(C) 3.67 mol	(G) 0.500 mol	
(D) 0.37 mol	(H) 5.45 g	

1. What is the mass of 0.042 mole Octane (C_8H_{18})?
2. What is the mass of 4.02 mol Barium nitrite $Ba(NO_2)_2$?
3. How many moles are there in 19.0 g of Fluorine (F_2)?
4. How many moles are there in 44.0 g of Sodium dihyrogen phosphate (NaH_2PO_4)?
5. How many moles are there in 1.04 g Sodium chloride (NaCl)?

Activity 3. Proper Label!

Safety inside the chemistry laboratory is important. As part of safety protocols in the laboratory all chemicals must be properly stored and labelled. Let us write the necessary information for each chemical in the laboratory.

Directions: Complete the table by providing the necessary information. Write your answer on a separate sheet of paper.

Substance	**Molecular Mass**	**Kind of particles**	**Mass (g)**	**No. of moles**	**No. of particles**
Gold (Au)		Atom	197	1	
Sugar ($C_2H_{22}O_{11}$)		molecule		2	
Carbon dioxide (CO_2)				3	
Sulfur (S)	32		64		

Activity 4. What's the number?

Let us do some dimensional analyses to practice your skills and apply what you have learned about mole-number of particles relationship

6.02×10^{23} particles = 1 mole

Directions: Convert the following units. Write your solution and answer on a separate sheet of paper.

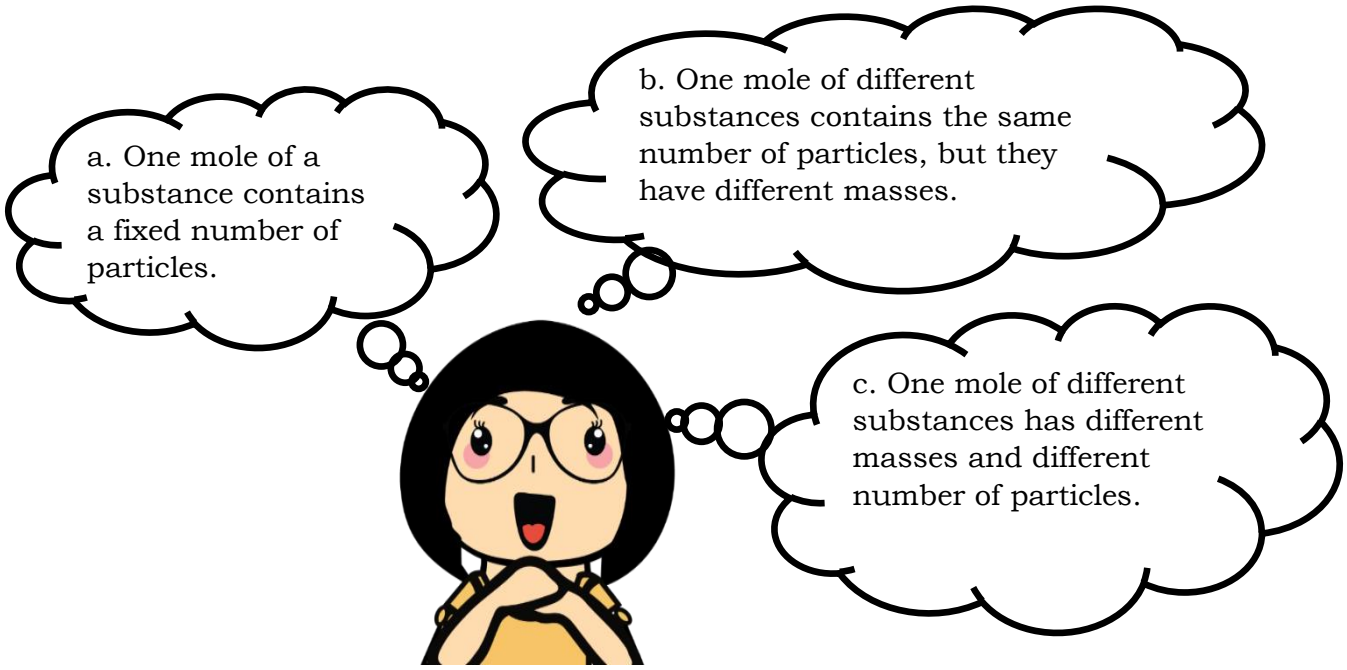
1. What is the number of particles in 0.500 mole of Al?
2. What is the number of moles of S in 1.8×10^{23} S atoms?
3. What is the number of particles in 1.5 moles of CO_2?
4. What is the number of moles of Zn in 4.22×10^{23} atoms?
5. How many moles is 25.2 g of Fe?

Activity 5. Are you related? (Mass, Mole, No. of particles)

You almost mastered the skills in expressing the mass of a substance using the mole concepts. Let us try to analyze the given data and answer the following questions. Write your answer on a separate sheet of paper.

Substance	No. of particles	No. of Moles	Molecular Mass
Water H_2O	6.02×10^{23}	1	18 amu
Gold (Au)	6.02×10^{23}	1	197 amu
Sugar ($C_{12}H_{22}O_{11}$)	6.02×10^{23}	1	342 amu
Salt (NaCl)	6.02×10^{23}	1	58 amu
Sulfur (S)	6.02×10^{23}	1	32 amu

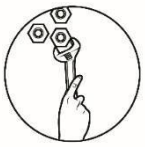
1. What is the relationship among mass, mole and no. of particles of a given substance?
2. Help Sally arrange her ideas the concept of mole. Which of these ideas about mole is incorrect? Why?



What I Have Learned

Determine the word/s that correctly complete s the statement. Write your answer on a separate sheet of paper.

1. The _____ is the sum average of the atomic weights of the atoms in its empirical formula.
2. The molecular mass of a molecule is its average mass as calculated by adding the _____ of the atoms in the molecular formula.
3. _____ is the unit use to express formula mass.
4. Molecular mass is used for _____ compounds.
5. _____ is the unit use to express molecular mass.
6. The quantity of a substance which contains the same number of particles is called _____.
7. The actual number of atoms in 12 g of Carbon-12 isotope is equal to _____ particles.
8. In counting the number of atoms, we use a constant number called _____.
9. The number of particles (atoms, molecules, ions) is equal to Avogadro's number 6.02×10^{23} in honor of the scientist _____.
10. In converting mass, number of moles of atoms or vice versa scientist use _____.

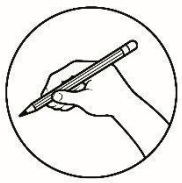


What I Can Do

There are so many applications of mole concepts around us. Can you solve this problem using the mole concept in expressing the mass, moles and number of particles of a substance?

Ammonium phosphate $(NH_4)_3PO_4$ is a compound that is often used by farmers as fertilizers. If Mang Ambo has 100 grams of this compound. Can you calculate its molecular mass, numbers of moles, and its number of particles? Write your answer on a separate sheet of paper.

A. Molecular mass of $(NH_4)_3PO_4$
B. Number of moles of $(NH_4)_3PO_4$
C. Number of particles



Assessment

Choose the letter of the best answer. Write your answers on a separate sheet of paper.

1. Which of these is the quantity of a substance containing the same number of particles?
   A. Density
   B. Mass
   C. Mole
   D. Volume

2. Which statement is TRUE about the different substance having the same number of moles?
   A. They have equal masses.
   B. They have equal numbers of particles.
   C. They have equal volumes per unit mass.
   D. They have the same amounts of energy.

3. Which molecule has the largest mass per molecule?
   A. H_2
   B. Cl_2
   C. CO_2
   D. C_2H_5OH

4. Which of these values represent the number of particles in one mole of a substance?
   A. $6.02x10^{22}$
   B. $6.02x10^{23}$
   C. $6.02x10^{24}$
   D. $6.02x10^{25}$

5. Who among these chemists and physicists made use of the mole concept to represent the number of particles in a substance?
   A. Amedeo Avogadro
   B. Jacques Charles
   C. John Dalton
   D. Robert Boyle

6. Which of these sets of units is used to represents molecular mass?
   A. g
   B. g/mol
   C. Kg
   D. mg

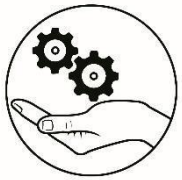
7. Which of these values is the correct molar mass for Sodium chloride (NaCl)?
   A. 58.5 g/mol
   B. 45.2 g/mol
   C. 38.1 g/mol
   D. 11.3 g/mol

8. Which is equivalent to one mole of $Ca(NO_3)_2$?
   A. 40 g $Ca(NO_3)_2$; 6.02×10^{23} particles
   B. 164 g $Ca(NO_3)_2$; 12.04×10^{23} particles
   C. 328 g $Ca(NO_3)_2$; 6.02×10^{23} particles
   D. 164 g $Ca(NO_3)_2$; 6.02×10^{23} particles

9. The molecular mass of water is 18 g/mol. How many moles of water is found in 6 grams of water (H_2O)?
   A. 0.52 mol
   B. 1.80 mol
   C. 0.33 mol
   D. 0.48 mol

10. What is the mass of 2.5 mol $CaCl_2$?
   A. 420 g
   B. 720 g
   C. 120 g

277 g



Additional Activities

We are almost done! You did great in the previous part. Sally cannot determine the mass of harvest on their farm; would you like to help her? Using your knowledge about the basic mole concept, let us try to calculate the given substances.

Directions: Solve the given problems below. Write you solution and answer on the box below.

1. How many sunflower seeds are equal to 3.50 moles of sunflower seeds?
2 How many strawberries are equal to 7.50 moles of strawberries?
3. How many moles of rice grains are equal to 1.807×10^{24} grains of rice?

Answer Key

What I Know

1. A	6. C
2. C	7. D
3. B	8. A
4. B	9. B
5. C	10. D

What's In

1. Diagram A
2. B and C
3. B has a double bond in its carbon while C has triple bond.
4. Hydrogen and Carbon

What's New

Dozen – 12

Case – 24

Ream – 500

Mole – 6.02×10^{23}

What's More

Activity 1. Molecular mass

1. 160 g/mol
2. 158 g/mol
3. 331 g/mol
4. 132 g/mol

Activity 2.
What's the code?

I	J	G	D	A

Activity 3. Proper Label!

Substance	Molecular mass	Kind of particles	Mass	No. of moles	No. of particles
Gold	197	Atom	197	1	6.02×10^{23}

Activity 4.
What's the number?

1. 3.01×10^{23} molecules
2. 0.299 moles

Sugar	342	Molecule	684	2	13.04x10²³
Carbon dioxide	44	Molecule	132	3	18.06x10²³
Sulfur	32	atom	64	2	12.04x10²³

Activity 5. Are you related? (Mass, Mole, No. of particles)

1. The no. of moles of a compound is related to its mass through the molar mass. The no. of moles is related to the number of particles through the Avogadro number.

2. The incorrect idea is letter B – The correct statement is different materials of one mole each have different masses but the same number of particles.

What I Have Learned

1. Formula Mass
2. Atomic weight
3. amu (atomic mass unit)
4. Covalent
5. g/mol (grams per mole)
6. Mole (mol)
7. 6.02 x10²³
8. Avogadro's number
9. Amedeo Avogadro
10. Dimensional analyses

What I can do

1. 149 g/mol

2. 0.67 mole

3. 4.03 x10²³

|

Assessment

1. C	6. B
2. B	7. A
3. B	8. D
4. B	9. C
5. A	10. D

Additional Activities

1. 2.11 x10²⁴ sunflower seeds

2. 4.54 x10²⁴ strawberries

3. 3.002 moles of rice grains

of S	
3. 9.03 x 10²³ molecules	
4. 7010 moles of Zn	
5. 0.451 moles of Fe	

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