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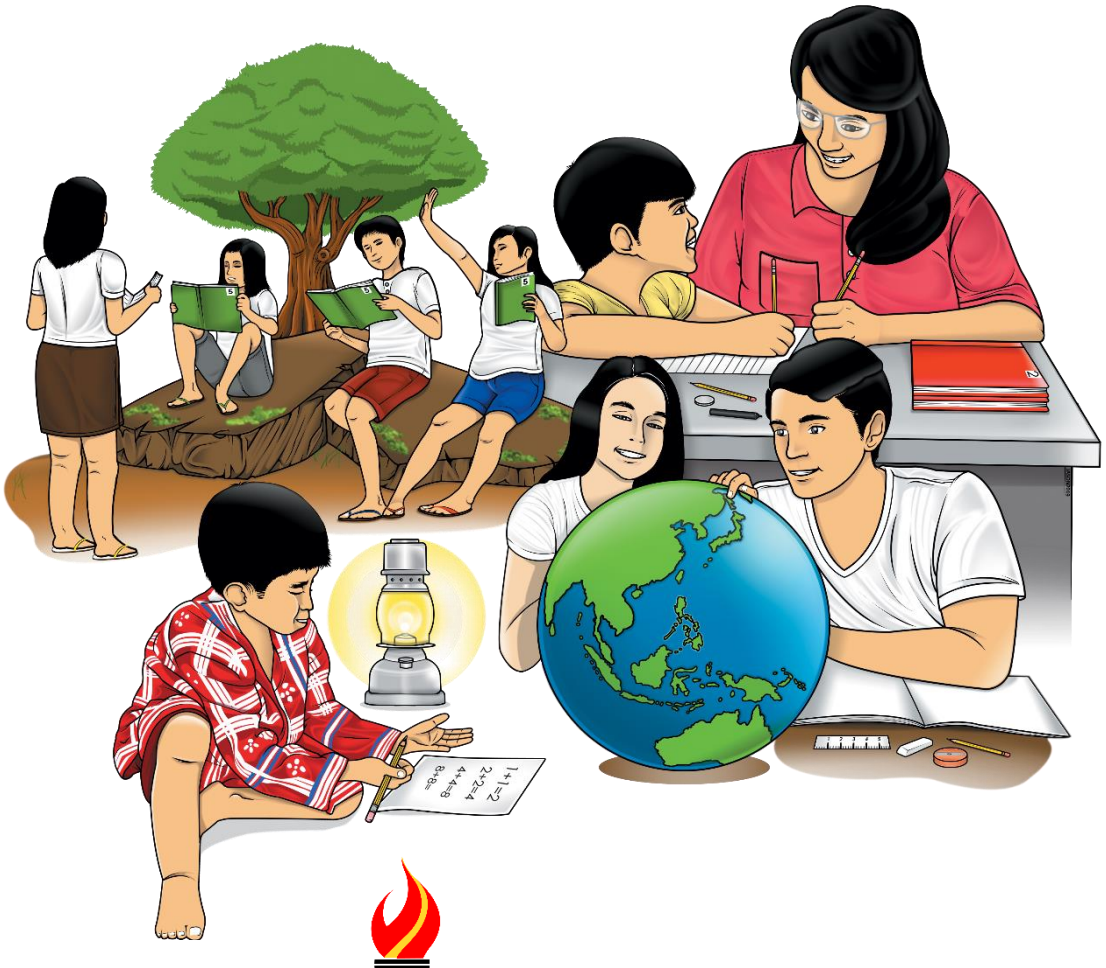
Science

Quarter 2 – Module 8:
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

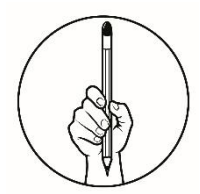
In the previous science lessons, the learners were introduced to the concept of mass. This can be a good foundation to start the mole concept.

The reason why learners need to understand this topic because most quantitative chemical calculations are based on the mole, an understanding of the mole is vital to the study of chemistry. An understanding of how the mole relates to mass, number of entities (atoms, molecules, ions, etc.). Based on researcher of Gulacar, Overton, Bowmanc, & Fyneweverd (2013) mole concept appears to be very complex for the learners, and extra effort must be exerted in order to make sure that this concept is properly understood.

In this module, the mole concept is strategically introduced by banking on the prior knowledge of the learners. Activities were designed in such a way that the starting activity makes use of the concepts they already know, and through a series of activities, they are led to the attainment of the desired competencies they need to develop. From counting and weighing, they will be able to apply mole concept in expressing the mass, number of moles, and particles of a given substance and computing its percentage composition after these lessons. Realistic problems involving mole concept in daily life scenarios were also provided for the learners to realize that this concept is not alien to them. Understanding this topic will make them wise consumers, good farmers, effective environmentalists, and well informed individuals.

This module will guide you more about the mole concept and its application in getting mass of a substance. So, don't miss this break to learn more with joy the following lessons:

- At the end of this module, you should be able to know the mole concept and use to express mass of substances; Code: S9MT-IIi-19.



What I Know

Multiple Choice: Read the statements carefully. Choose the letter of your answer and write it on your answer sheet.

1. What is the SI unit for measurement of number of particles in a substance?
   a. Kilogram
   b. Mole
   c. ampere
   d. Kelvin

2. Which of the following is NOT a representative particle?
   a. molecule
   b. photon
   c. anion
   d. atom

3. Aspirin has a chemical formula of $C_9H_8O_4$. What is the mass of 0.40 mol of aspirin?
   a. 45 g
   b. 72 g
   c. 160 g
   d. 10.8 g

4. How many particles of any substance is present in one mole?
   a. 6.02×10^{22} particles
   b. 6.02×10^{23} particles
   c. 6.02×10^{24} particles
   d. 6.02×10^{25} particles

5. If one dozen of egg is 12 pieces of eggs, how many pieces of paper are there in one Ream?
   a. 100 pieces
   b. 250 pieces
   c. 350 pieces
   d. 500 pieces

6. What is the molar mass of $AuCl_3$?
   a. 96 g
   b. 103 g
   c. 303 g
   d. 626.5 g

7. What is the equivalent of Avogadro's number of representative particles?
   a. 1 liter
   b. 2 liters
   c. 1 mole
   d. 2 mole

8. What is the equivalent of one Mole of a substance?
   a. molar mass
   b. atomic mass
   c. electron mass
   d. neutron mass

9. Given one mole of $AuCl_3$, what is its equivalent mass?
   a. 303 g
   b. 130 g
   c. 231.5 g
   d. 85 g

10. How many atoms of hydrogen are there in 2 moles of NH_3?
    a. 5×10^{23} atoms
    b. 3.01×10^{23} atoms
    c. 3.61×10^{24} atoms
    d. 4×10^{23} atoms

Lesson 1 Mole Concept

What I Need to Know

A mole is a quantity that allows chemists to convert from the atomic scale to macroscopic scale.

In everyday life, pieces of matter are quantified by measuring its mass or counting it. In the market, we do not buy grain products like mongo or rice by counting the grains because of its size, but rather through its mass. It is easier for us to quantify an object through its mass rather than counting each piece especially for small items.

At the end of the lesson, you will be able to express understanding of the mole concept.

Specifically, after going through this module, you will be able to:

1. Relate the mole concept to Avogadro's number
2. Apply the mole concept to represent particles and vice versa
3. Apply the mole concept in determining mass of a substance

What's New

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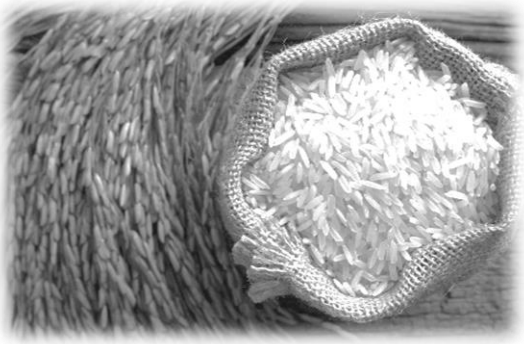

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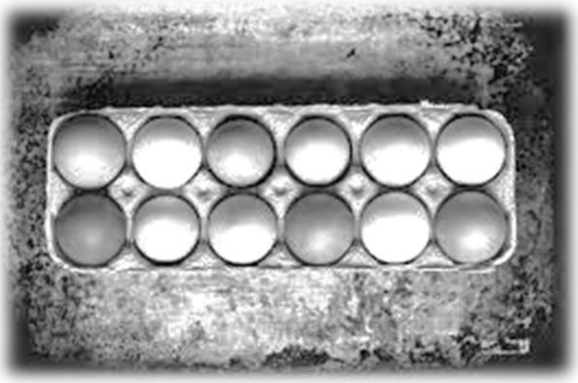

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Have you tried counting the number of grains of rice in a cup? How about the number of eggs in a tray? Which task is more difficult to do? The above pictures show how hard it is to quantify objects when they are made up of small particles.

The words below are expression of a certain amount or quantity, including examples of how it is used. Can you give other examples?

- Pair, 2 (dice, people)
- Dozen, 12 pieces (eggs, doughnuts, etc.)
- Century, 100 years
- Gross, 144 (pencils, straws, etc.)
- Ream, 500 (bond paper)
- Giga, 1 billion (Gigabytes of computer memory)

The expression dozen is a widely used like when you buy eggs or doughnuts. Did you know that one ream of bond paper has 500 pieces? A pair of shoes is 2 pieces of the same shoe. This is a technique used to easily understand how much is present in an object.

Matching Type: Match Column A (measuring units) to Column B (equivalent number).

Column A	**Column B**
_____1. 1 dozen of eggs	a. 2
_____2. 1 gross of leaves	b. 20
_____3. 1 ream of bond paper	c. 144
_____4. 1 pair of slippers	d. 24
_____5. 1 quire of writing paper	e. 500
_____6. 1 score of peanut seeds	f. 12

What is It

Any measurement can be broken down into two parts – the numerical value and the unit which the quantity is expressed into. For example, when the mass of a ball is measured to be 2 kilograms, the numerical measurement is '2' and the unit is 'kilogram'.

The mole concept is a convenient method of expressing the amount of a substance. When dealing with particles at an atomic or molecular level, even one gram of a pure element is known to contain a huge number of atoms. This is where the mole concept is widely used. It primarily focuses on the unit known as a 'mole', which is a count of a very large number of particles.

The most important concepts in this unit are the following:

- ✓ Mole (mol) is the SI unit used to measure the amount of substance whose number of particles is the same as the number of atoms of carbon in exactly 12g of Carbon-12
- ✓ Avogadro's number is the number of representative particles in a mole (6.02×10^{23})
- ✓ Atom is the smallest particle of an element
- ✓ Moles can be used to count "representative particles:" atoms, molecules, ions, and formula units.
- ✓ The representative particle of an ionic compound is the formula unit.
- ✓ The representative particle of a covalent compound is the molecule.
- ✓ The representative particle of an element is the atom.

The number 6.02214076 x 10^{23} is popularly known as the *Avogadro constant* or *Avogadro's numbe*r and is often denoted by the symbol 'N_A'. The elementary entities that can be represented in moles can be atoms, molecules, monoatomic/polyatomic ions, and other particles (such as electrons).

For example, one mole of a pure carbon-12 (^{12}C) sample will have a mass of exactly 12 grams and will contain 6.02214076 x 10^{23} number of ^{12}C atoms. The number of moles of a substance in a given pure sample can be represented by the following formula:

$$\boldsymbol{n = N/N_A}$$

Where n is the number of moles of the substance (or elementary entity), N is the total number of elementary entities in the sample, and N_A is the Avogadro constant.

Note:

The word "mole" was introduced around the year 1896 by the German chemist Wilhelm Ostwald, who derived the term from the Latin word moles meaning a 'heap' or 'pile.

The number of moles of a molecule may not always be equal to the number of moles of its constituent elements. For example, a mole of water contains N_A number of H_2O molecules. However, each water molecule contains 2 hydrogen atoms and one oxygen atom. Therefore, one mole of H_2O contains 2 moles of hydrogen and one mole of oxygen.

Sample Problem:

How many molecules are there in 4.0 moles NaCl (*Table Salt*)?

To answer this question, you have to consider this:

1 mole = 6.02 x 10^{23} particles

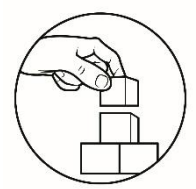
Using the dimensional analysis approach, you will be able to convert the number of moles to its equivalent amount in the number of particles.

$$4.0 \text{ moles NaCl (table Salt)} \times \frac{6.02 \times 10^{23} \text{ molecules of NaCl}}{1 \text{ mole NaCl}} = 2.41 \times 10^{24} \text{ molecules NaCl}$$

Do this:

How many particles are there in:

a. 0.5 mole of Nitrogen
b. 1.2 moles ammonia (NH_3)
c. 8 moles propane (C_3H_8)



What's More

Activity 1*: " Tama o MOLE.li"*

Objective: to identify the number of moles in a given substance

Materials needed:

- activity sheet
- ballpen
- calculator

Procedure:

Remember that there are 6.02×10^{23} particles in one mole of a substance. Using this information, solve the given problems below.

1 mole = 6.02 × 10^{23} particles such as atoms, ions, or molecules

1. 1 mole of hydrogen ions (H^+) consist of how many particles?
2. How many moles of copper are in 6,000,000 atoms of copper?
3. How many grams are present in a sample containing 2.71×10^{24} atoms of iron?
4. How many atoms of carbon and sulfur are needed to make one molecule of carbon disulfide (CS_2)?
5. How many moles of carbon atoms and sulfur atoms does it take to make one mol of carbon disulfide (CS_2) molecules?

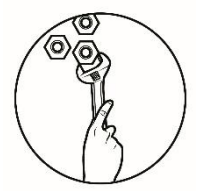
What I Have Learned

Analysis and Interpretation

As a leaner, you know that a dozen signifies 12 items.

Suppose you do not have sufficient items to make a dozen. You then decided to make a new counting unit. You called this unit (a)_____ (*create your own unit name*). Each of your (b)_____ (same name unit) package contains 8 items.

1. A _____ (your unit name) of pencil will have 8 pencil.
2. A _____ of pretzels has 8 pretzels.
3. A _____ of molecules of water has 8 molecules of water.
4. A _____ of particles has 8 particles.
5. A _____ of atoms of iron has 8 atoms of iron.
6. A _____of formula units of salt has 8 formula units of salt.
7. How many Hershey's Kisses are in 2 _____ (created unit name)?
8. How many caramels are in 10 _____(created unit name)?
9. How many popcorn are in 400 _____ (created unit name)



What I Can Do

Singing in Mole: Writing Learners Lyrics to Express Learning

Instruction: Based on the discussions above, make a song using Mole concept.

Rubric for Song Writing:

	Excellent 4	**Good 3**	**Fair 2**	**Poor 1/0**
NEATNESS Song Lyrics	Copy of lyrics is turned in 0-2 spelling and grammatical errors	Copy of lyrics is turned in with 3-4 spelling and grammatical errors	Many spelling and grammatical errors present. Marks on the paper.	No paper or incomprehensible paper turned in.
CREATIVE Completeness of the written work: Does it Make Sense?	Words correctly describe the process completely and thoroughly in a unique manner.	Words correctly describe the process completely and thoroughly with a couple of mistakes.	Words are incomprehensible and do not make sense. The words do not describe the assignment.	No creative thinking by the author. Copied paper or copied from another person, book, or other written, spoken, or taped work.
PROCESS Correct use of the process.	The process is named correctly and the description is correct with 0-1 mistakes.	The process is correctly named and the description has 2-4 mistakes.	The process is correctly named but an incorrect description is made. The process description has more than 4 errors.	No process addressed by the author. The process described in the work is incorrect.
Presentation How the Science song was presented.	Presenters were flawless in presenting the song.	Presenters were heard and maintained a serious composure, but made a couple of mistakes while presenting.	Presenters were heard but occasionally were not loud enough or silly, made several mistakes while presenting the song.	Presenters could not be heard or could not get through the song in a serious manner, completely unprepared.
Length of Song How long was the song	The song was between 2:30 and 6 minutes.	The song was between 2:30 to 2:15.	The song was between 1:45 and 2:15.	The song was under 1:45.

Lesson 2 Molar Mass

What's In

From the previous lesson, you knew that a mole is the SI unit to measure the amount of particles in a substance. For different substances, one mole always contains 6.02 x 10^{23} particles but they have different masses. Let's look at the Periodic Table of elements. For example, we have carbon, hydrogen, oxygen, phosphorus, potassium and Sulphur. Have you notice any difference on their atomic mass? Well, the mass of each element is different from the others, in the same manner that different compounds have different masses. Refer to the given table below for the examples.

A mole is an SI unit to measure the amount of a substance and contains 6.02 x 10^{23} particles. Examples are given below:

SUBSTANCE	***CHEMICAL FORMULA***	***NUMBER OF PARTICLES***	***MOLAR MASS (g/mole)***
Sodium chloride (Table salt)	NaCl	6.02 x 10^{23}	1 mole of Na x 22.98 g/mol = 22.98 g/mol 1 mole of Cl x 35.45 g/mol = 35.45 g/mol **Total = 58.43 g/mol**
Water	H_2O	6.02 x 10^{23}	2 mole of H x 1 g/mol = 2 g/mol 1 mole of O x 16 g/mol= 16 g/mol **Total = 18.00 g/mol**

What's New

Activity 1

Consider a part of the Periodic Table below. Try to locate the elements and identify their atomic mass and complete the given table below.

H 1.00																	He
Li 6.94	Be 9.01											B 10.81	C 12.01	N 14.00	O 16.00	F 19.00	Ne 20.18
Na 22.98	Mg 9.01											Al 26.98	Si 28.08	P 30.97	S 32.06	Cl 35.45	Ar 39.95
K 39.10	Ca 40.08	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr

NAME	SYMBOL	MASS (g)
Example: Boron	B	10.81
1. Carbon	C	
2. Sodium	Na	
3. Potassium	K	

What is It

Atomic and Molecular Mass

The atomic mass of an element is the mass of one atom of the element expressed in atomic mass units (amu). It accounts for the abundance of the various isotopes of the element and assigns an average value to the mass of one atom of the element. For example, the atomic mass of carbon is 12.011 atomic mass units since carbon samples generally contain 98.89% of the carbon-12 isotope, 1.11% of carbon-13, and trace amounts of carbon-14. However, the atomic masses of these isotopes are different.

The atomic mass of a carbon-12 atom is 12 atomic mass units, but that of a carbon-13 atom is 13 amu. The atomic mass of an element is roughly equal to the sum of all the protons and neutrons present in its nucleus.

The molecular mass of an element is the sum of the atomic masses of all its constituent elements. This quantity is also represented in terms of atomic mass units. Therefore, the molecular mass of water is equal to the sum of the atomic masses of its constituents – hydrogen and oxygen. The atomic mass of hydrogen is 1.00794 amu and that of oxygen is 15.9994. Since water molecules contain 2 hydrogen atoms and only one oxygen atom, the molecular mass of H_2O is 18.0154 amu.

Molar Mass

The molar mass of a substance is defined as the total mass of one mole of the substance. It is often represented in terms of 'grams per mole' (g/mol). However, the SI unit of this quantity is kg/mol. Molar mass can be represented by the following formula:

Molar mass of a Substance = (Mass of the Substance in grams)/(Number of Moles)

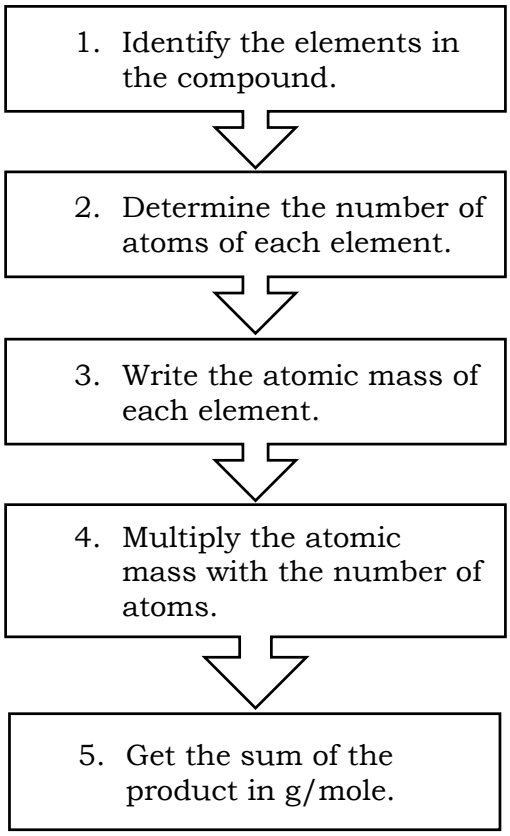
For example, the molar mass of water is approximately 18.015 g/mol, which is the mass of 6.02×10^{23} number of water molecules.

Before we proceed, answer the following activity seriously using the periodic table from the previous page.

Practice 1:

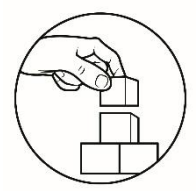
Element name	***Mole***	***Molar mass***	***Grams (g)***
Sodium	1		23.00
Hydrogen	1		1.01

Steps to follow to calculate for the molar mass:



For example:

ELEMENT	**NO. OF ATOM**	**ATOMIC MASS**	**MOLAR MASS(g/mole)**
Hydrogen	1	1.01	1.01
Oxygen	1	16.00	16.00
Carbon	1	12.01	12.01
methane (CH_4)	1 atom of C 4 atoms of H	1 atom of C x 12.01 g/mol = 12.01 g/mol 4 atoms of H x 1.01 g/mol = 4.04 g/mol	16.05 g/mol



What's More

Activity

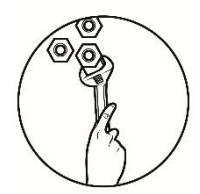
This time you will calculate the molar mass of the compound. Fill-up the given table below. You can use the periodic table as a reference.

COMPOUND	ELEMENT	NO. OF ATOMS	ATOMIC MASS	MOLAR MASS (g/mole)
Example: NaCl	Na	1	22.98	58.43
	Cl	1	35.45	
1. hydrogen peroxide, H_2O_2				
2. Baking soda, $NaHCO_3$				
3. Lime, CaO				
4. Lye, NaOH				

What I Have Learned

Complete the given table by applying the concepts you have learned.

SUBSTANCE	REPERESENTATIVE PARTICLE	MOLAR MASS(g/mole)
Silver, Ag		107.87
Oxygen gas, O_2	molecules	
Sulfur dioxide, SO_2		64.06



What I Can Do

Activity

Using the concepts of mole and molar mass, complete the table below. You may use a Periodic Table of Elements to determine the values of atomic mass.

SUBSTANCE	Representative particle	Molar mass (g/mole)	No. of moles	No. of particles
1. mercury (Hg)			1	
2. nitrogen gas (N_2)			1	
3. sucrose ($C_{12}H_{22}O_{11}$)			2	

Summary

- The mole is defined as the number of atoms contained in exactly 12 grams of carbon-12 (the isotope). There are 6.0221415 x 1023 particles in a mole. Remember, a mole is just a number (like dozen) and you can have a mole of anything.
- The concept of a mole is based on Avogadro's Hypothesis (equal volumes of all gases at the same temperature and pressure contained the same number of molecules) and the number of particles in a mole (6.0221415 x 1023) is commonly referred to as Avogadro's number (typically rounded to 6.02 x 1023 for most calculations).
- Because atomic masses, and the number of particles in a mole, are both based on the isotopic atomic mass of the isotope carbon-12, the mass of any substance expressed in atomic mass units is numerically equal to the molar mass of the substance in grams per mole. Thus, exactly 12 grams of carbon-12 contains exactly a mole of carbon atoms; likewise, 31.9988 grams of O2 contains 6.02214 x 1023 oxygen molecules (note, six significant figures)
- To convert the number of moles of a substance into the mass of a substance, you simply need to multiply (moles x molar mass).
- To convert the mass of a substance into the number of moles, you simply need to divide the mass by the molar mass.
- To convert the number of moles of a substance into the number of particles of that substance, you simply need to multiply (moles x Avogadro's number).

Assessment

Multiple Choice: Read the statements carefully. Choose the letter of your answer and write it on the space provided before the number.

1. What is the molar mass of sodium hydroxide, NaOH?
   a. 38.0 g/mole
   b. 44 g/mole
   c. 23 g/mole
   d. 40.01 g/mole
2. What is the unit of molar mass?
   a. Grams
   b. grams/mole
   c. mole
   d. mole/gram
3. How many moles are there in 32.3 grams of carbon dioxide,CO_2?
   a. 0.73
   b. b. 32.3
   c. 44.01
   d. 1421.52
4. What is the molar mass of Carbon, C?
   a. 12.01 g
   b. 12.01 g/mole
   c. 12.01 mole
   d.12.01 mole/gram
5. 2.50 mole of oxygen gas,O_2 ,has the mass?
   a. 6 g
   b. 32 g
   c. 40 g
   d. 80 g
6. To determine the formula mass of a compound you should
   a. add up the atomic masses of all the atoms present.
   b. add up the atomic masses of all the atoms present and divide by the number of atoms present.
   c. add up the atomic numbers of all the atoms present.
   d. add up the atomic numbers of all the atoms present and divide by the number of atoms present.
7. What is the SI unit for measurement of number of particles in a substance?
   a. Kilogram
   b. Mole
   c. ampere
   d. Kelvin
8. A mole of a chemical substance represents
   a. the mass of the substance that will combine with 12.0 g of carbon.
   b. the mass of the substance that will combine with 100.0 g of oxygen.
   c. 6.02×10^{23} particles of the substance.
   d. 6.02×10^{-23} grams of the substance.
9. Which of the following samples contains the greatest number of atoms?
   a. 1 mole of CO_2
   b. b. 2 moles of He
   c. 3 moles of N_2O
   d. 4 moles of CO
10. Why is the mole concept important?
    a. It is useful when converting between grams and atoms or molecules.
    b. It gives us a convenient way to express large numbers.
    c. It can be applied to any type of particle representative.
    d. all of the above

Answer Key

LESSON 1: Mole Concept

What I Know (Pretest)

1. b
2. b
3. b
4. b
5. d
6. c
7. c
8. a
9. a
10. c

What's New

1. f
2. c
3. e
4. a
5. d
6. b

What's more

Activity 1. **Mole Concepts**

1 mole = 6.02 × 1023 particles such as atoms, ions, or molecules

1. 6.02×10^{23}
2. 9.96×10^{-18} moles of copper *(just divide 6,000,000 atom of copper to 6.02x10*^{23} *atom of copper)*
3. 251.1 grams of iron.
   - *Amount of Fe = (2.71x1024)/(6.02x10*^{23}*) = 4.50mol*
   - *The atomic mass of Fe is 55.8*
   - *Mass of Fe = 4.50 x 55.8 = 251.1 g*
4. 1 atom of C and two atoms of S
5. 1 mol of C and 2 mol of S

What is it?

a. 3.01×10^{23} atoms
b. 7.224×10^{23} molecules
c. 4.816×10^{24} molecules

What I have Learned (Analysis and Interpretation)

a. Own answer (name)
b. Own answer (name)

1. Same answer to a and b.
2. Same answer to a and b.
3. Same answer to a and b.
4. Same answer to a and b.
5. Same answer to a and b.
6. Same answer to a and b.
7. 16 Hershey's kisses
8. 80 caramel
9. 3,200 popcorn

Lesson 2 Molar Mass

What's New

1.12.01
2.22.98
3.39.1

What's More

COMPOUND	ELEMENT	NO. OF ATOMS	ATOMIC MASS	MOLAR MASS (g/mole)
1.hydrogen peroxide, H_2O_2	H O	2 2	1.01 16.00	34.02
2.Baking soda, $NaHCO_3$	Na H C O	1 1 1 3	23.00 1.01 12.00 16.00	84.01
3.Lime, CaO	Ca O	1 1	40.08 16.00	56.08
4.Lye, NaOH	Na O H	1 1 1	23.00 16.00 1.01	40.01

What I have Learned

SUBSTANCE	REPERESENTATIV E PARTICLE	MOLAR MASS(g/mole)
1.Silver ,Ag	atom	
2.Oxygen gas, O_2	molecules	32.00
3.Sulfur dioxide, SO_2	molecules	

What I can do

`SUBSTANCE	Representative particle	Molar mass(g/mole)	No. of moles	No. of particles
1.mercury(Hg)	atom	200.59		6.02×10^{23}
2.nitrogwn gas(N_2)	molecules			6.02×10^{23}
3.sucrose($C_{12} H_{22} O_{11}$)	molecules	342.34		1.2×10^{24}

Post Assessment

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

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