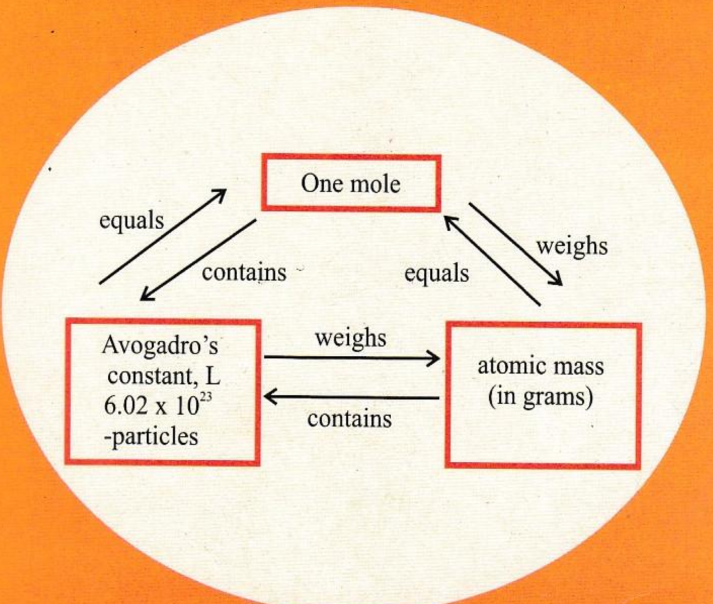
SCIENCE TEACHERS ASSOCIATION OF NIGERIA

CHEMISTRY PANEL SERIES 9

TEACHING MOLE CONCEPT, GAS LAWS & CHEMICAL CALCULATIONS



A HANDBOOK FOR CHEMISTRY TEACHERS

PART 3

PAPER 01

SIMPLIFYING ATOM-MASS-MOLE RELATIONSHIPS IN ELEMENTS AND COMPOUNDS

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Introduction

Chemistry is a science of processes and products. Teaching the product alone without the process amounts to incomplete chemistry teaching. It is therefore necessary to build simple processes of knowledge acquisition that is essentially directed towards students' – centred activities using hands-on, minds-on and heads-on activities to give chemistry meaning and relevance among its learners. Enriching concept knowledge of learners using simple to apply pedagogical approach motivates students' interest in learning chemistry and makes teaching enjoyable and learner friendly. A teacher goes beyond the subject matter to consider possible ways knowledge could be imparted to the learner to enhance optimum performance. This the teacher does by selecting teaching strategies that match learners' background, aspiration, experience, intelligence, age, available resources and the concept under consideration (Onwioduokit, 2013). At the senior secondary school level where chemistry is first exposed to learners, it is important to use simple strategies to bring the principles, laws, and generalizations of chemistry to arrive at scientific facts. This is enable students try and apply skills for problem-solving for life-long learning of chemistry. This will demystify the abstract nature students consider chemistry to be.

It is suggested that prior to teaching amount of substance and the mole, it is important that students have a firm grasp of underlying key concepts such as relative atomic mass and that they understand the idea of the mole before being presented with problems involving numerical operations to be able to predict and solve problems. This can be facilitated by linking key ideas and explaining the origin of the mole and the associated quantity amount of substance.

Claesgens and Stacy (2003) suggest that teaching mole concept should focus on linking atomic model to students' experience with matter to improve their understanding of the mole. They further suggested the use of analogies with everyday objects to help clarify the meaning 'relative' and make clear connection between ideas (e.g. amount of substance, number of entities, mole, Avogadro's number before presenting number problems). Most students are unable to grasp the concepts of mole and Avogadro's number in relation to its theoretical background because teachers themselves have shallow knowledge concept to effectively handle the topics. Teachers find it difficult knowing which tasks to assign students first after giving theoretical information as regards atoms, mass and mole relationship. Simplifying concepts would make teaching and learning easier.

Relative Atomic Mass

The relative atomic mass of an element is the number of times one atom of the element is as heavy as one-twelfth of the mass of one atom of carbon-12. This can be expressed as

Relative atomic mass = (12 × mass of one atom of the element)/(Mass of one atom of carbon-12)

Examples of relative atomic mass

Hydrogen (H) = 1; Carbon (C) = 12; Nitrogen (N) = 14; Oxygen (O) =16;
Chlorine (Cl) = 35.5.

Simple steps outlined below could be followed for calculating relative formula mass to build upon knowledge of mass of element in various compounds: They are;

1. Write the formula of the compound;

2. Write the number of each atom in the formula;

3. Insert the relative atomic mass for each of the atom;

4. Calculate the total mass for each element;

5. Add up the total mass for the compound

Example: Calculate the relative formula mass of the compound with the formula; H_2SO_4

(H = 1, S = 32, O = 16)

$H_2SO_4 = (2 \times H) + (1 \times S) + (4 \times O)$

$= (2 \times 1) + (1 \times 32) + (4 \times 16)$

$= 2 + 32 + 64 = 98$

Atoms, Moles and Avogadro's constant

The Mole

Before teaching the mole concept, it is necessary to teach basic concepts of chemistry to students, such as atoms, molecules, ions, radicals, and use techniques of simple calculations like addition, subtraction, division and multiplication to enhance students' numerical grasp of the mole concept.

The mole is the basic unit of the amount of a substance. This unit contains a large number of particles, about 6.02×10^{23} particles. This number is called the Avogadro constant (L). The mole is the amount of substance which contains as many elementary particles as there are atoms in 12.00 g of carbon-12. Therefore, I mole of carbon-12 has a mass of 12 g. One mole of any substance contains the same number of particles, be they ions, atoms or molecules.

Molar Mass

The mass of one mole of a chemical substance expressed in grams is known as the molar mass (M). Its unit is gram per mol ($gmol^{-1}$). Hence, molar mass of a substance will be its formula mass expressed in grams (Ababio, 2009).

Molar mass = Mass of one mole = formula mass

For example, the molar mass of carbon-12 is 12.0 g; that is,

molar mass of carbon is 12.0 g/mol;

that of sodium is 23.0 g/mol; etc.

Molar mass of hydrogen atoms (H) is 1.0 $gmol^{-1}$ and contains 6.02×10^{23} atoms of hydrogen (H = 1).

Avogadro constant, L is numerically equal to 6.02×10^{23}, so:

1 mole of carbon atoms weighs 12.0 g and contains 6.02×10^{23} atoms

1 mole of sodium atoms weighs 23.0 g and contains 6.02×10^{23} atoms

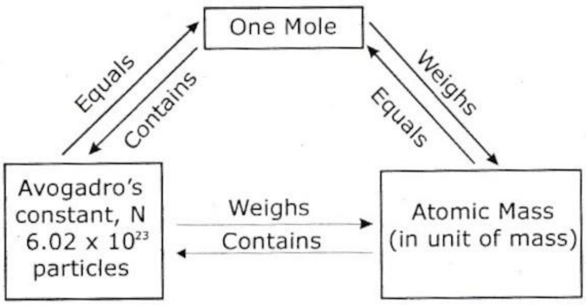

Figure 1: Inter-relationships for Mass-Mole-Avogadro's Constant (Ojokuku, 2010).

Mass – mole Relationships in Elements and Compounds

These terms can be simplified by the teacher engaging students in as many numerical activities as possible in the class and giving home work for better understanding of concepts.

Examples:

1. Calculate the amount, in moles, of atoms present in 16.0 g of calcium (Ca = 40)

Solution:

40 g of Ca = 1 mole

1 g of Ca = $^1/_{40}$ mole

$\therefore$ 16 g of Ca = $^1/_{40} \times 16$ = 0.40 mole

2. How many atoms are present in 0.30 mole of sodium ?

1 mole of Na contains 6.02×10^{23} atoms

$\therefore$ 0.3 mole of Na contains

$6.02 \times 10^{23} \times 0.3$ atoms = 1.06×10^{23} atoms

3. Calculate the mass of 0.20 mole of sodium Hydroxide, NaOH (Na = 23, O = 16, H = 1)

Molar mass of NaOH = 23 + 16 + 1 = 40 $gmol^{-1}$

1 mole of NaOH = 40 g

∴ 0.2 mole of NaOH = 40 × 0.2 = 8.0 g

Atom-Mass-Mole Relationship: Avogadro's constant (L)

One mole of an element contains a fixed number of atoms; the Avogadro's constant, L, 6.02×10^{23} atoms. Increasing the number of atoms X leads to an increase in the amount, n in moles.

Mathematically: $X \alpha n$

i.e. $^X/_n = k$

k is the Avogadro's constant L, i.e.

(Number of atom, X) /(Amount, n) = L.

Dividing the mass of one mole (Molar mass, M) of an element, by the Avogadro's constant, N, the mass of an atom is obtained, i.e.

(Molar Mass)/(Avogadro's constant)

= mass of an atom (g)

Guide students accordingly, by working along with them in solving problems.

Examples:

1. How many atoms are in 2.0 g of calcium? [Ca = 40; Avogadro's constant = 6.02×10^{23} mol^{-1}]

Let x represent the number of atoms in 2.0 g of calcium

40 g of calcium = 6.02×10^{23} atoms

2 g of calcium = x atoms

Cross multiplying:

$40x = 6.02 \times 10^{23} \times 2$ atoms

$x = 6.02 \times 10^{23} \times 2$ atoms

$= 3.01 \times 10^{22}$ atoms

2. What is the mass of 6.02×10^{24} atoms of Magnesium?

(Mg = 24, Avogadro constant = 6.02×10^{23})

Solution:

6.02×10^{23} atoms of magnesium weigh 24 g.

∴ 6.02×10^{24} atoms weigh

$(24 \times 6.02 \times 10^{24}/(6.02 \times 10^{23})$ g

$= (24 \times 10)$ g = 240 g

3. How many moles are in 8.02×10^{23} atoms of magnesium? [Mg = 24, Avogadro number = 6.02×10^{23} mol^{-1})

Solution:

Amount of atoms, n =

(Number of atoms)/(Avogadro number, L)

$= (8.02 \times 10^{23})/(6.02 \times 10^{23})$

= 1.33 mol.

Conclusion

Simplifying chemical calculations for do-it-yourself engagement will stimulate learners' interest on numerical concepts in chemistry.

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