Education and Culture DG

Lifelong Learning Programme

Teaching innovatively (with focus on ICT) and its impact on the quality of education"

LESSON PLAN

CHEMISTRY

Teacher : Fazilet TURNA

Level : 10th grade

Unit : The Mole Concept and Chemical Calculations

Topic : The Mole Concept

Time : 40 minutes

Lesson Objectives :

1)To Explain the mole concept with the particle concept and the number of 6,02.10^{23}

2)To use ICT as a succesful tool when learning.

Method : Question – Answer Method,grup discussion, teaching method

Materials : Publicatrons about the topic, coarse book

Assumptrons :

1- Explaining the number of 6,02.10^{23} equals 1 mole.
2- Explaining that 1 mole element mass is called the mole mass and 1 mole compound mass is called the mole mass.

Procedures

1. Teaching the topic.
2. Making students ask each other questions
3. Making students do pair work and prepare two questions
4. Making students give particle samples the save number as the number of Avagadro
5. Showing the mole concept by a pomegranate
6. Solving problems

SUMMARY

1 mole particle's being equal to 6,02.10^{23} is explained.The number 6,02.'s being Avagadro is stated.That the number of Avagadro and the mole increase at the same rate is explained through examples.1 mole element mass being called the mole mass and 1 mole compound mass being called the mole mass are expained through examples.

Evalvation : Solving the mole problems on the prepared softwares.

Click on to play the game.

ANNEX

The Mole

Objectives

_ Explains why chemists work in moles

_ Describes how to perform chemical calculations, involving masses and gas

volumes using moles

_ Defines 'percentage yield'

_ Explains how to work out which substance is the limiting reagent in a

chemical reaction

Molecular mass

The idea of molecular mass was introduced in Chapter 3. This is the mass of one

molecule of substance on the atomic mass scale. Molecular masses are calculated

using the atomic masses of the constituent atoms. A list of approximate atomic

masses for atoms of elements is shown in Table 8.1. You should use these for calculations,

unless you are instructed otherwise.

Examples of calculations of molecular mass

m(H2O) _ 1 _ 1 _ 16 _ 18u

m(C6H5Cl) _ (6 _ 12) _ (5 _ 1) _ (35.5) _ 112.5 u

$m(H2SO4)$ _ (2 _ 1) _ (32) _ (4 _ 16) _ 98u

Substances such as sodium chloride (Na+, Cl_) and copper(II) nitrate (Cu2+, 2NO3 _)

consist of ions (not molecules) and the term 'molecular mass' is not strictly appropriate.

Nevertheless the 'formula mass' of these substances are calculated in a similar

way to neutral molecules. Examples are

m(Na+, Cl_) _ 23 _ 35.5 _ 58.5 u

m(Cu2+, 2NO3

_) _ (63.5) _ 2(14 _ 16 _ 16 _ 16) _ 187.5 u

Contents

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Moles

The mole

How do you identify a chemist? One simple way is to ask the question: ‘What is a mole?’ A keen gardener will answer ‘A small furry animal that digs holes in the lawn’; a doctor or nurse will answer ‘a dark spot on skin’; and the head of a company may answer ‘a spy’. A chemist will always answer ‘a pile of particles’ or, being more specific, ‘just over six hundred thousand trillion particles’. When chemists have to calculate amounts of reacting substances they constantly work (and think!) in moles;

that is why they will not hesitate to give the answer described above.

Why do chemists have to work in moles? Consider a reaction

A _ B _ AB

You have already learned that the equation tells us that one particle of A reacts with one particle of B to form one particle of the compound AB. If a chemist wishes to get an exact amount of A to react with an exact amount of B, and not have excess A or B left over, then equal numbers of the particles of A and B must be reacted together.

Element Symbol Approximate

atomic mass/u

Hydrogen H 1

Helium He 4

Carbon C 12

Nitrogen N 14

Oxygen O 16

Fluorine F 19

Neon Ne 20

Sodium Na 23

Magnesium Mg 24

Aluminium Al 27

Phosphorus P 31

Sulfur S 32

Chlorine Cl 35.5

Potassium K 39

Element Symbol Approximate

atomic mass/u

Calcium Ca 40

Iron Fe 56

Nickel Ni 59

Copper Cu 63.5

Zinc Zn 65

Bromine Br 80

Silver Ag 108

Tin Sn 119

Iodine I 127

Barium Ba 137

Gold Au 197

Mercury Hg 201

Lead Pb 207

Uranium U 238

Table 8.1 Approximate atomic masses of selected elements

Calculating the molecular and formula mass

Write down the mass (u) of the following:

(i) nitric acid, HNO3

(ii) magnesium sulfate, MgSO4

(iii) ethyne, C2H2

(iv) sulfur molecules, S8

(v) ethyl ethanoate, CH3COOC2H5

(vi) hydrated iron(III) nitrate, Fe(NO3)3 9H2O

(vii)one atom of neon.

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The particles might be atoms, molecules or ions. Such particles are very small, so in order that the amounts involved are practical to work with, a great many particles of A must be added to the same number of particles of B.

Balances in the laboratory are used to weigh amounts of substance in grams and not atoms, molecules or ions, so it is *not* useful to weigh out say 1 g of A to react with 1 g of B – A and B are different substances so their particles *do not have the same mass*. Equal masses of A and B *will not contain the same number of particles*.

Chemists work in moles, because *one mole of any substance contains the same number of particles*. Note that the *name* of the amount is mole and the symbol for the *unit* is mol.

Avogadro's constant

The number of particles (atoms, molecules or ions) in one mole of a substance is defined as being

the number of atoms contained in exactly 12 grams of carbon-12.

This number is very large and has been found by experiment to be

602200000000000000000000 or 6.022 _ 1023,

often approximated to 6 _ 1023 mol_1

This value is called Avogadro's constant and is symbolized *N*A.

From Table 8.1,

m(C) _ 12u

m(He) _ 4u

m(H_2O)_ 18u

m(H_2) _ 2u

and we can reason as follows:

● One atom of carbon is three times as heavy as one atom of helium. Therefore, onethousand atoms of carbon are three times as heavy as one-thousand atoms of helium. Therefore, if a sample of carbon has three times the mass of a sample of helium they must have the same number of atoms, so that 12 g of carbon and 4 g of helium must each contain the same number of atoms – this number is numerically equal to N_A. Similar reasoning produces the following conclusions:

● One molecule of water is 4.5 times as heavy as one atom of helium, so 18 g of water contains N_A *molecules* of water, whereas 4 g of helium contains N_A *atoms* of helium.

● One atom of helium is twice as heavy as one molecule of hydrogen, so 4 g of helium containsN_A *atoms* of helium and 2 g of hydrogen contains N_A *molecules of hydrogen*.

Generalizing, the mass of a substance that contains N_A *particles is numerically equal to the atomic mass or molecular mass of that substance expressed in grams*. This mass is called the molar mass of the substance because it is the mass of one mole of that substance.

The symbol for molar mass is *M*. Its units are normally grams per mole (g mol_1).

For example,

M(H_2O) _ 18 g mol_1

See Table 8.2 and Fig. 8.1.

Relationship between moles, molar mass and the mass of

substance

To convert a mass of substance into moles the following equation can be used:

amount of substance in moles _

mass

molar mass

Notice that units of molar mass are grams per mol, then the units of mass must be

grams.

The rearranged forms of this equation are also useful:

molar mass _

mass

amount of substance in moles

and

mass _ amount of substance in moles _ molar mass

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10 atoms of Ne 10 molecules of H_2O 10 ion pairs of

Na^+ and $Cl^–$ in NaCl

Fig. 8.1 An equal number of

moles of neon, water and

sodium chloride.

Table 8.2 The relationship between mass, molar mass and the number of

moles for selected substances. (For simplicity *N*A has been taken as

exactly 6 _ 1023 mol_1)

Substance Mass of Formula of Molar mass Number of moles Number of

substance substance /g mol_1 of substance in particles in the

/g the stated mass stated mass

Carbon 12 C 12 1 6 _ 1023

Carbon 120 C 12 10 6 _ 1024

Oxygen gas 32 O2 32 1 6 _ 1023

Oxygen gas 3.2 O2 32 0.1 6 _ 1022

Sodium chloride 58.5 NaCl 58.5 1 6 _ 1023*

Sodium chloride 0.0585 NaCl 58.5 0.001 6 _ 1020*

Benzene 78 C6H6 78 1 6 _ 1023

Benzene 7800 C6H6 78 100 6 _ 1025

* This is the number of Na_,Cl_ ion pairs.

Moles, molar mass and Avogadro's constant

(i) Neon gas consists of single atoms. What mass of neon contains 6 _ 1023 atoms?

(ii) How many potassium ions are there in 94 g of potassium oxide, 2K+, O2_?

(iii) Magnesium metal consists of magnesium atoms. What mass of magnesium contains

6 _ 1022 atoms?

(iv) What is the molar mass of copper(II) sulfate, CuSO4?

Example 8.1

How many moles of hydrated copper(II) sulfate (CuSO4 · 5H2O)

are contained in 5.00 g of the substance?

_ Answer

m(CuSO4 · 5H2O) _ (63.5 _ 32 _ 4(16) _ 5(18)) _ 249.5 u

therefore,

M(CuSO4 · 5H2O) _ 249.5 g mol_1.

The amount of copper sulfate in moles _

mass

molar mass

_

5.00

249.5 _ 0.0200mol

0.059 mol of calcium carbonate (CaCO3) is required in an

experiment. What mass of CaCO3 needs to be weighed out?

_ Answer

M(CaCO3) _ 100g mol_1

Therefore, mass of calcium carbonate

_ amount of calcium carbonate in moles _ molar mass

_ 0.059 _ 100 _ 5.9 g

0.20 mol of a compound containing carbon and hydrogen has a

mass of 3.2 g. What is the molecular mass of the compound?

What is its likely formula?

_ Answer

molar mass _

mass

amount of substance in moles

_

3.2

0.20

_ 16g mol_1

Since *M*(compound) _ 16 g mol_1, *m*(compound) _ 16u.

Carbon has an atomic mass of 12. The molecule is likely to be methane (CH4) with

m(CH4) _ 12 _ 1 _ 1 _ 1 _ 1 _ 16u

_ Comment

Where there could be confusion, you should always be careful to specify *exactly* the substance you are referring to. For example the statement ‘1 mol of hydrogen’ could mean 1 mol of H atoms *or* 1mol of H_2 molecules. These have different molar masses of 1 g mol_1 and 2 g mol_1, respectively.

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Fig. 8.2 An experiment to estimate the Avogadro constant.

Simple experiment to estimate the Avogadro constant

Oil spreads out on the surface of water as far as it can. Theoretically, this could be until a layer one molecule thick is present. The oil used in this experiment is oleic acid, $C_{18}H_{34}O_2$ (Fig 8.2).

If one small drop of a solution of oil is dropped on to the surface of some water in a suitable container it spreads out in a circular layer. If the surface of the water is previously covered with a fine layer of talc, the diameter of the oil layer can be estimated with a ruler. Assuming the layer of oil is one molecule thick, the approximate thickness of an oil molecule and an estimate of the size of the Avogadro constant, *N*A can be calculated. Specimen results are shown below.

To find the thickness of an oil molecule

Volume of oil in drop of solution _*y* cm3.

Density of oil _0.891 gcm_3.

Diameter of oil layer on water _*d* cm.

Area of circular oil layer on water __*r2* =__(*d*/2)2cm2.

Volume of oil layer __*r*2*h*___(*d*/2)2_*h*

(think of the layer as a cylinder, one molecule thick and the thickness of the molecules

_*h*).

Since the volume of the layer must be equal to the volume of the drop,

y _ _ _ (*d*/2)2 _ *h*

So *h*, the thickness of a molecule of oil, can be calculated.

To estimate the value of the Avogadro constant *N*A

Assume that the molecules are cubes, of side *h*.

Then volume of a molecule _*h*3.

The molecular mass of the oil = 282

Volume of 1 mol of oil =

molar mass

=

282

density 0.891

Then *N*A =

volume of 1 mol of molecules

volume of 1 molecule

More calculations involving moles, mass, and molar mass

1. What is the mass of:

(i) 1 mol of N atoms

(ii) 4 mol of Fe atoms

(iii) 1.50 mol of Cl_ ions

(iv) 20 mol of Na2SO3?

2. How many moles of substance are

present in:

(i) 40 g of calcium metal (Ca)

(i) 123.2 g of CCl4

(iii) 0.49 g of SO4

2_

(iv) 14 g of N2?

3. A pure solid consists of either (i) sodium

chloride (NaCl) (ii) copper carbonate (CuCO3)

or (iii) sodium carbonate (Na2CO3). 1.06 g of

the solid contains 0.01 mol of compound.

What is the chemical identity of the solid?

4. Calculate:

(i) the number of molecules of sulfur (S8) in

16 g of solid sulfur.

(ii) the number of aluminium ions in 0.056 g

of aluminium oxide (2Al3+, 3O2_).

(*N*A = 6 _ 1023 mol_1).

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Determining formulae by experiment

To work out a formula by experiment, it is necessary to find out how many moles of each element combine together to make the compound. Magnesium metal, in the form of a strip (*magnesium ribbon*) is heated in air until all the magnesium is combined with oxygen. The diagrams in Fig. 8.3 show different steps in the experiment, in order.

Some sample results are:

Mass of crucible _ 20.40 g

Mass of crucible _ Mg _ 22.26 g

Mass of crucible _ magnesium oxide _ 23.52 g

The formula of magnesium oxide can be worked out by answering the following questions (answers in brackets):

1. Find the mass of magnesium used in the experiment (22.26 – 20.40 _ 1.86 g).

2. Calculate how many moles of magnesium atoms the answer to 1. represents (1.86/24_0.078).

3. Find the mass of magnesium oxide formed (23.52 – 20.40 _3.12 g).

4. Find the mass of oxygen that combines with magnesium (3.12 – 1.86 _1.26 g).

5. How many moles of oxygen atoms does the answer to 4. represent? (1.26/16 _ 0.079)

6. What is the ratio of the number of moles of magnesium atoms to number of moles of oxygen atoms (0.078:0.079) as a whole number? (almost exactly 1:1).

7. The formula of magnesium oxide is therefore MgO.

Percentage composition by mass

The percentage of an element in a compound is found by using the formula of the compound and the atomic masses of the elements in the compound. It is more correctly called the percentage composition by mass of the element in that compound.

The percentage composition by mass of an element is given by the formula

molar mass of element _ number of atoms of the element in the formula of the compound

_ 100

molar mass of compound

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Fig. 8.3 Experiment to

determine the formula of

magnesium oxide.

The answer you obtain from this calculation should only give you some idea of the **magnitude** of N_A. There are a number of oversimplifications in the above reasoning, especially the assumption that the layer of oil is only one molecule thick.