

Chemistry I HD –
Chapter 6

Chemistry I –
Chapter 10

ICP - Handouts

The Mole



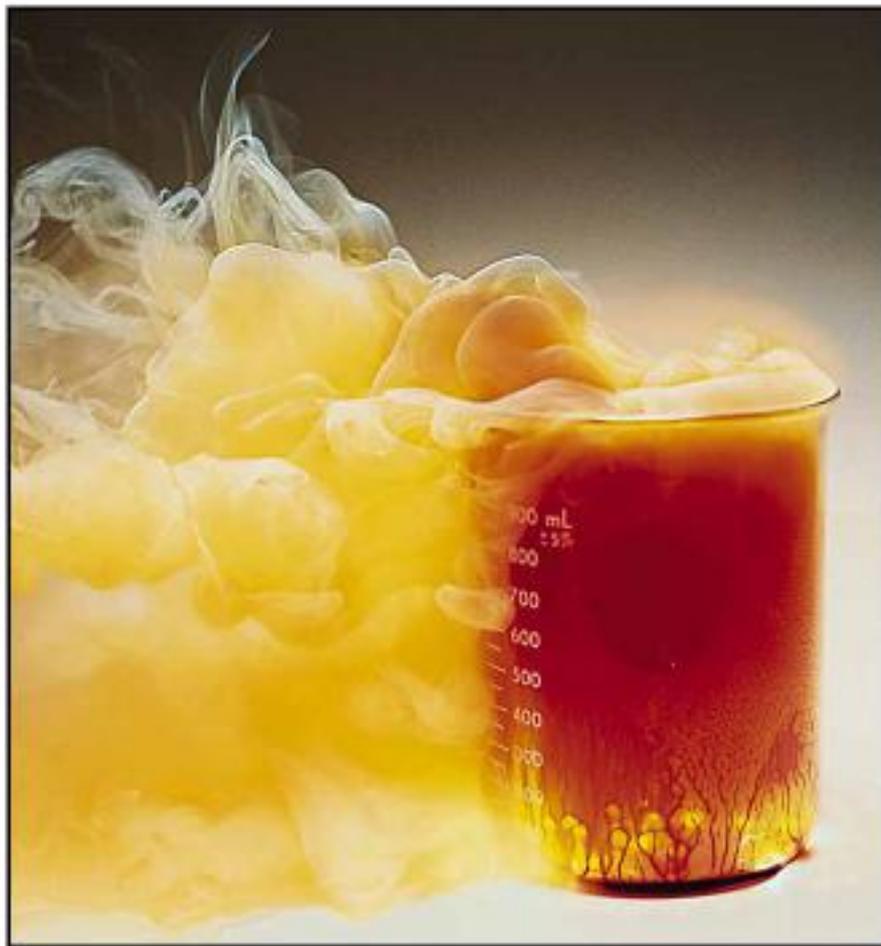
SAVE PAPER AND INK!!! When you print out the notes on PowerPoint, print "Handouts" instead of "Slides" in the print setup. Also, turn off the backgrounds (Tools>Options>Print>UNcheck "Background Printing")!

6.02 X 10²³



STOICHIOMETRY

- the study of the quantitative aspects of chemical reactions.

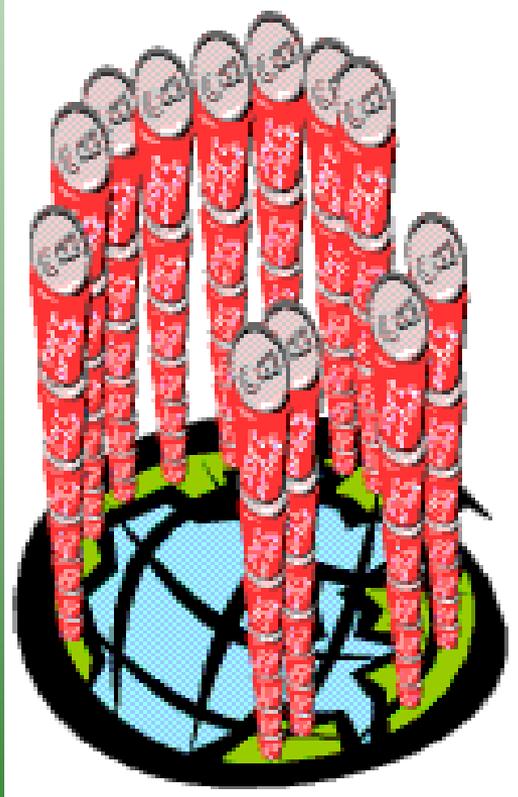


The Mole

- A counting unit
- Similar to a dozen, except instead of 12, it's 602 billion trillion
602,000,000,000,000,000,000,000
- 6.02×10^{23} (in scientific notation)
- This number is named in honor of **Amedeo Avogadro (1776 – 1856)**, who studied quantities of gases and discovered that no matter what the gas was, there were the same number of molecules present



Just How Big is a Mole?



- Enough soft drink cans to cover the surface of the earth to a depth of over 200 miles.
- If you had Avogadro's number of unpopped popcorn kernels, and spread them across the United States of America, the country would be covered in popcorn to a depth of over 9 miles.
- If we were able to count atoms at the rate of 10 million per second, it would take about 2 billion years to count the atoms in one mole.

Everybody Has Avogadro's Number!

But Where Did it Come From?

- It was NOT just picked!
It was MEASURED.
- One of the better
methods of measuring
this number was the
Millikan Oil Drop
Experiment
- Since then we have
found even better ways
of measuring using x-
ray technology

Learning Check

Suppose we invented a new collection unit called a rapp. One rapp contains 8 objects.

1. How many paper clips in 1 rapp?

a) 1

b) 4

c) 8

2. How many oranges in 2.0 rapp?

a) 4

b) 8

c) 16

3. How many rapps contain 40 gummy bears?

a) 5

b) 10

c) 20

The Mole

- 1 dozen cookies = 12 cookies
- 1 mole of cookies = 6.02×10^{23} cookies

- 1 dozen cars = 12 cars
- 1 mole of cars = 6.02×10^{23} cars

- 1 dozen Al atoms = 12 Al atoms
- 1 mole of Al atoms = 6.02×10^{23} atoms

**Note that the NUMBER is always the same,
but the MASS is very different!**

**Mole is abbreviated mol (gee, that's a lot
quicker to write, huh?)**

A Mole of Particles

Contains 6.02×10^{23} particles

1 mole C = 6.02×10^{23} C atoms

1 mole H₂O = 6.02×10^{23} H₂O molecules

1 mole NaCl = 6.02×10^{23} NaCl “molecules”

(technically, ionics are compounds not molecules so they are called formula units)

6.02×10^{23} Na⁺ ions and

6.02×10^{23} Cl⁻ ions

Avogadro's Number as Conversion Factor

$$\frac{6.02 \times 10^{23} \text{ particles}}{1 \text{ mole}}$$

or

$$\frac{1 \text{ mole}}{6.02 \times 10^{23} \text{ particles}}$$

Note that a particle could be an atom OR a molecule!

Learning Check

1. Number of atoms in 0.500 mole of Al

- a) 500 Al atoms
- b) 6.02×10^{23} Al atoms
- c) 3.01×10^{23} Al atoms

2. Number of moles of S in 1.8×10^{24} S atoms

- a) 1.0 mole S atoms
- b) 3.0 mole S atoms
- c) 1.1×10^{48} mole S atoms

Molar Mass

- The Mass of 1 mole (in grams)
- Equal to the numerical value of the average atomic mass (get from periodic table)

1 mole of C atoms = 12.0 g

1 mole of Mg atoms = 24.3 g

1 mole of Cu atoms = 63.5 g

Other Names Related to Molar Mass

- **Molecular Mass/Molecular Weight:** If you have a single molecule, mass is measured in amu's instead of grams. But, the molecular mass/weight is the same numerical value as 1 mole of molecules. Only the units are different. (This is the beauty of Avogadro's Number!)
- **Formula Mass/Formula Weight:** Same goes for compounds. But again, the numerical value is the same. Only the units are different.
- **THE POINT:** You may hear all of these terms which mean the *SAME NUMBER*... just different units

Learning Check!

Find the molar mass

(usually we round to the tenths place)

A. 1 mole of Br atoms = 79.9 g/mole

B. 1 mole of Sn atoms = 118.7 g/mole

Molar Mass of Molecules and Compounds

Mass in grams of 1 mole equal numerically to the sum of the atomic masses

$$1 \text{ mole of } \text{CaCl}_2 = 111.1 \text{ g/mol}$$

$$1 \text{ mole Ca} \times 40.1 \text{ g/mol}$$

$$+ 2 \text{ moles Cl} \times 35.5 \text{ g/mol} = 111.1 \text{ g/mol CaCl}_2$$

$$1 \text{ mole of } \text{N}_2\text{O}_4 = 92.0 \text{ g/mol}$$

Learning Check!

A. Molar Mass of $\text{K}_2\text{O} = ?$
Grams/mole

B. Molar Mass of antacid $\text{Al}(\text{OH})_3 = ?$
Grams/mole

Learning Check

Prozac, $C_{17}H_{18}F_3NO$, is a widely used antidepressant that inhibits the uptake of serotonin by the brain. Find its molar mass.

Calculations with Molar Mass



Converting Moles and Grams

Aluminum is often used for the structure of light-weight bicycle frames. How many grams of Al are in 3.00 moles of Al?

3.00 moles Al \longrightarrow ? g Al



1. Molar mass of Al **1 mole Al = 27.0 g Al**

2. Conversion factors for Al

$$\frac{27.0\text{g Al}}{1 \text{ mol Al}} \quad \text{or} \quad \frac{1 \text{ mol Al}}{27.0 \text{ g Al}}$$

3. Setup **3.00 moles Al** **x** $\frac{27.0 \text{ g Al}}{1 \text{ mole Al}}$

Answer **= 81.0 g Al**

Learning Check!



The artificial sweetener aspartame (Nutra-Sweet) formula $C_{14}H_{18}N_2O_5$ is used to sweeten diet foods, coffee and soft drinks. How many moles of aspartame are present in 225 g of aspartame?

Atoms/Molecules and Grams

- **Since 6.02×10^{23} particles = 1 mole
AND
1 mole = molar mass (grams)**
- **You can convert atoms/molecules to moles and then moles to grams! (Two step process)**
- **You can't go directly from atoms to grams!!!! You MUST go thru MOLES.**
- **That's like asking 2 dozen cookies weigh how many ounces if 1 cookie weighs 4 oz? You have to convert to dozen first!**

Calculations



**Everything must go through
Moles!!!**

Atoms/Molecules and Grams



How many atoms of Cu are present in 35.4 g of Cu?

$$\frac{35.4 \text{ g Cu}}{63.5 \text{ g Cu}} \times \frac{1 \text{ mol Cu}}{1 \text{ mol Cu}} \times 6.02 \times 10^{23} \text{ atoms Cu}$$

$$= 3.4 \times 10^{23} \text{ atoms Cu}$$

Learning Check!

**How many atoms of K are present in
78.4 g of K?**

Learning Check!



What is the mass (in grams) of 1.20×10^{24} molecules of glucose ($\text{C}_6\text{H}_{12}\text{O}_6$)?

Learning Check!

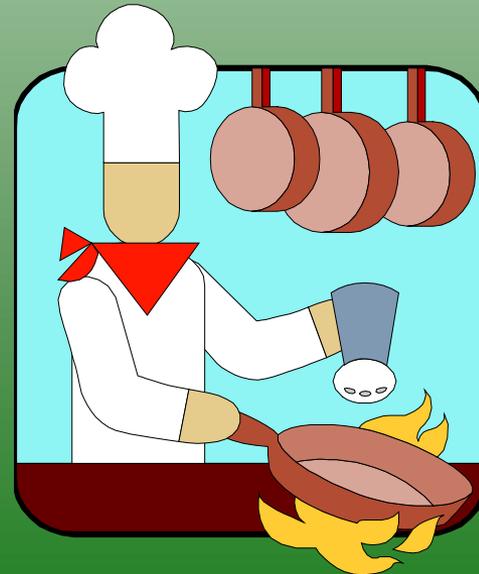
How many **atoms** of O are present in 78.1 g of oxygen?

$$\begin{array}{c}
 \frac{78.1 \text{ g } \cancel{\text{O}_2} \left| \frac{1 \text{ mol } \cancel{\text{O}_2}}{32.0 \text{ g } \cancel{\text{O}_2}} \right| 6.02 \times 10^{23} \text{ molecules } \cancel{\text{O}_2} \left| \frac{2 \text{ atoms O}}{1 \text{ molecule } \cancel{\text{O}_2}} \right.}{\phantom{\frac{78.1 \text{ g } \cancel{\text{O}_2} \left| \frac{1 \text{ mol } \cancel{\text{O}_2}}{32.0 \text{ g } \cancel{\text{O}_2}} \right| 6.02 \times 10^{23} \text{ molecules } \cancel{\text{O}_2} \left| \frac{2 \text{ atoms O}}{1 \text{ molecule } \cancel{\text{O}_2}} \right.}}
 \end{array}$$

Percent Composition

What is the percent carbon in $C_5H_8NO_4$ (the glutamic acid used to make MSG monosodium glutamate), a compound used to flavor foods and tenderize meats?

- a) 8.22 %C
- b) 24.3 %C
- c) 41.1 %C



Chemical Formulas of Compounds ²⁸

(HONORS only)

- Formulas give the relative numbers of atoms or moles of each element in a formula unit - always a whole number ratio (the law of definite proportions).

NO_2 2 atoms of O for every 1 atom of N

1 mole of NO_2 : 2 moles of O atoms to every 1 mole of N atoms

- If we know or can determine the relative number of moles of each element in a compound, we can determine a formula for the compound.

Types of Formulas

(HONORS only)

- Empirical Formula

The formula of a compound that expresses the *smallest whole number ratio* of the atoms present.

Ionic formula are always empirical formula

- Molecular Formula

The formula that states the *actual* number of each kind of atom found in *one molecule* of the compound.

To obtain an *Empirical Formula* (HONORS only)

30

1. Determine the mass in grams of each element present, if necessary.
 2. Calculate the number of *moles* of each element.
 3. Divide each by the smallest number of moles to obtain the *simplest whole number ratio*.
1. If whole numbers are not obtained* in step 3), multiply through by the smallest number that will give all whole numbers

* Be careful! Do not round off numbers prematurely

A sample of a brown gas, a major air pollutant,³¹ is found to contain 2.34 g N and 5.34g O. Determine a formula for this substance.

require *mole* ratios so convert grams to moles

moles of N = $\frac{2.34\text{g of N}}{14.01\text{ g/mole}}$ = 0.167 moles of N

moles of O = $\frac{5.34\text{ g}}{16.00\text{ g/mole}}$ = 0.334 moles of O

Formula: $\text{N}_{0.167}\text{O}_{0.334}$



(HONORS only)

Calculation of the Molecular Formula (HONORS only)

A compound has an empirical formula of NO_2 . The colourless liquid, used in rocket engines has a molar mass of 92.0 g/mole. What is the *molecular formula* of this substance?

Empirical Formula from % Composition

33

(HONORS only)

A substance has the following composition by mass: 60.80 % Na ; 28.60 % B ; 10.60 % H

What is the empirical formula of the substance?

Consider a sample size of 100 grams

This will contain 28.60 grams of B and 10.60 grams H

Determine the number of moles of each

Determine the simplest whole number ratio