The Mole

Mole- 8.3

Molar Mass- 8.4

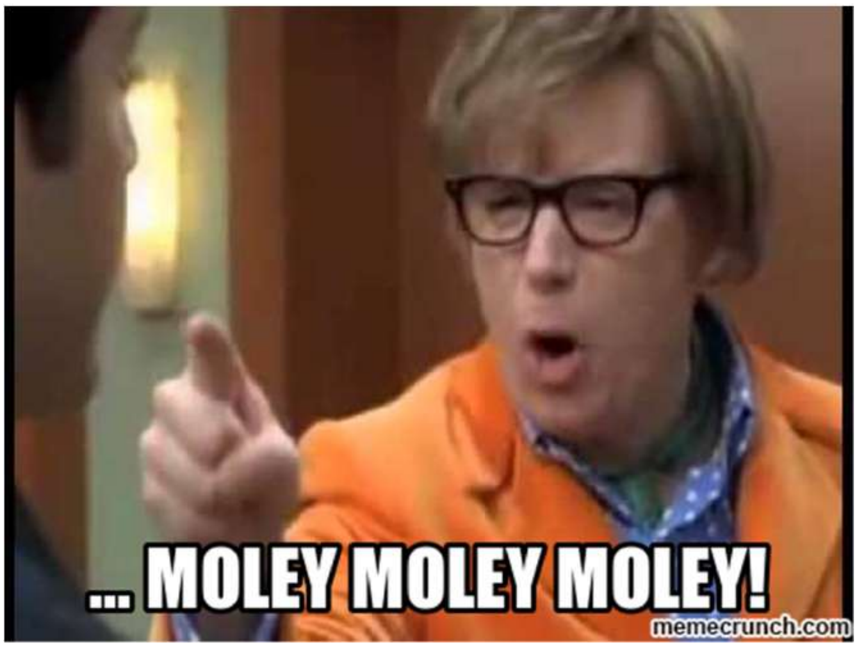
Formula Calculations

Average Atomic Mass for Carbon

- Even though natural carbon does not contain a single atom with mass 12.01, for calculation purposed, we consider carbon to be composed of only one type of atom with a mass of 12.01 amu (atomic mass unit)
- This enables us to count atoms of natural carbon by weighing a sample of carbon

The Mole

What is a mole?



The Mole

- A counting number/unit (like a dozen)
- Also called Avogadro's number (N_a)
  - This number is named in honor of Amedo Avogadro (1776-1856) who studies quantities of gases and discovered that no matter which gas he studied, there were the same number molecules present.
- $6.022x10^{23}$
- 602,200,000,000, 000,000, 000,000
- 602.2 billion trillion
- 1 mole = $6.022 x10^{23}$

The Mole

1 dozen cookies = 12 cookies

1 mole of cookies = 6.022×10^{23} cookies

1 dozen cars = 12 cars

1 mole of cars = 6.022×10^{23} cars

1 dozen Al atoms = 12 Al atoms

1 mole of Al atoms = 6.022×10^{23} atoms

The NUMBER is always the same, but the MASS is very different!

Molar Mass

The number equal to the number of Carbon atoms in exactly 12 grams of pure C-12

1 mole of anything = 6.022×10^{23} units of that thing (Avogadro's number)

1 mole C = 6.022×10^{23} C atoms = 12.01 g C

Molar Mass

Molar Mass: The mass of 1 mole of an element or compound

- atomic mass tells the atomic mass units per atom (amu)
- Molar Mass tells the mass in grams per mole (g/mol)

Calculating Molar Mass of Compounds

Guidelines:

- List each element in the compound
- How many atoms are there of each element
- Look up the mass of each element
- Multiply the amount of atoms by the mass
- Add the masses to find the Molar Mass for the compound

Molar Mass

Moles	Atoms	Mass
1 mol He	6.022×10^{23} atoms He	4.00g He
1 mol C	6.022×10^{23} atoms C	12.01 g C
1 mol Ag	6.022×10^{23} atoms Ag	107.87 Ag
1 mol of H2O	6.022×10^{23} molecules H_2O	18.02 g H_2O

H 2x 1.01 = 2.02
<u>O 1x 16.00 = 16.00</u>
________________= 18.02g H_2O

Molar Mass Practice

Mass in grams of one mole of the substance:

Molar Mass of N_2 =

Molar Mass of CO_2 =

Molar Mass of $Ba(NO_3)_2$ =

Molar Mass of $CuSO_4{*}2H_2O$=

Cu 1 x 63.55
S 1 x 32.07
O 6 96.00
H 4 4.04

195.66 g

Cu 1 x 63.55
S 1 x 32.07
O 4 x 16.00
H_2O 2 x 18.02

195.66 g $CuSO_4 \cdot 2H_2O$

Concept Check

moles → atoms (Avogadro's #)

Calculate the number of Iron atoms in a 4.48 mole sample of Iron

$$\frac{4.48 \text{ mol Fe}}{} \left| \frac{6.022 \times 10^{23} \text{ atoms Fe}}{1 \text{ mol Fe}} \right.$$

2.70×10^{24} atoms Fe

Concept Check

atoms ← g

Calculate the number of copper atoms in a 63.55 g sample of copper.

100 g

$$\frac{63.55\ g\ Cu}{} \times \frac{1\ mol\ Cu}{63.55\ g\ Cu} \times \frac{6.022 \times 10^{23}\ atoms\ Cu}{1\ mol\ Cu}$$

6.022×10^{23} atoms Cu

Mass Percent of an Element

$$Mass\% = \frac{mass\ of\ element\ in\ compound}{mass\ of\ compound} \text{ x } 100\%$$

For Carbon Dioxide: (CO_2)

C 1 x 12.01 = 12.01

O 2 x 16.00 = 32.00

= 44.01

$$\frac{12.01}{44.01} x\ 100 = 27.29\%$$

$$\frac{32.00}{44.01} x\ 100 = 72.71\%$$

Empirical Formula

could have more than 1 compound w/same EF

- consists of the symbols for the elements combined in a compound, with subscripts showing the *smallest whole-number mole ratio* of the different atoms in the compound

$C_3H_6O_3$ $C_6H_{12}O_6$ → $C_1H_2O_1$

$C_1H_2O_1$

- <u>Guidelines:</u>
  - –Convert each element into moles
    - •If given in percent, assume to have 100g
  - – Make it look like a formula
  - –Divide by the smallest molar number
  - –If needed, make it a whole number

Writing Empirical Formulas

If a compound has 94g oxygen and 6g hydrogen, what is the empirical formula?

Concept Check

- The composition of adipic acid is 49.3% C, 6.9% H, and 43.8% O (by mass). What is the empirical formula?

Molecular Formula

- The actual formula for a molecular compound
- It has not been simplified

X (empirical formula) = molecular formula

X (empirical formula mass) = molecular formula mass

Guidelines:

- Solve for x to find the multiplier
- Multiply the empirical formula by the multiplier to get the correct molecular formula

Molecular Formula

Empirical formula = CH

Molecular Formula = (empirical formula)$_n$

[n = integer]

X (empirical formula) = molecular formula

Molecular Formula = C_6H_6= $(CH)_6$

Concept Check

- the empirical formula of a compound is known to be N_2O_3. It was found experimentally that its molar mass is 228.06g/mol. What is the compound’s molecular formula?

Concept Check

The composition of adipic acid is 49.% c, 6.9% H, and 43.8% O (by mass). The molar mass of the compound is about 146g/mol. What is the molecular formula.

Challenge

- Caffeine, a stimulant found in coffee (1.2% dry weight), team (3% dry weight), a chocolate (0.2% dry weight), contains 49.48% C, 5.15% H, 28.87% N, and 16.49% O by mass and has a molar mass of 194.2g/mol. Determine the molecular formula of caffeine.