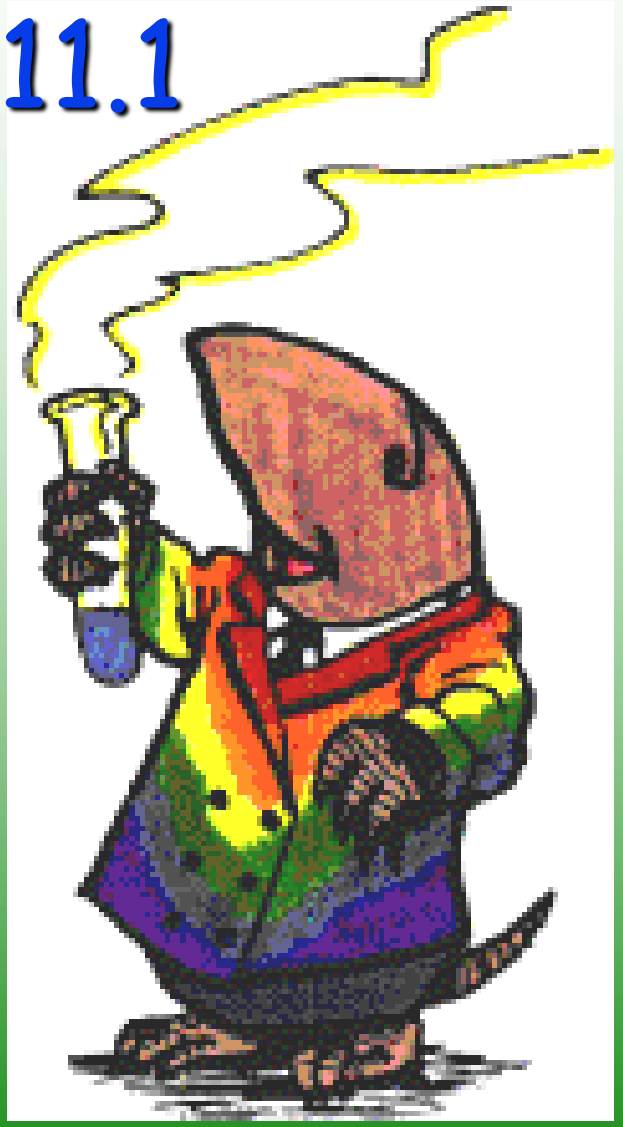
The Mole
Review Notes 11.1



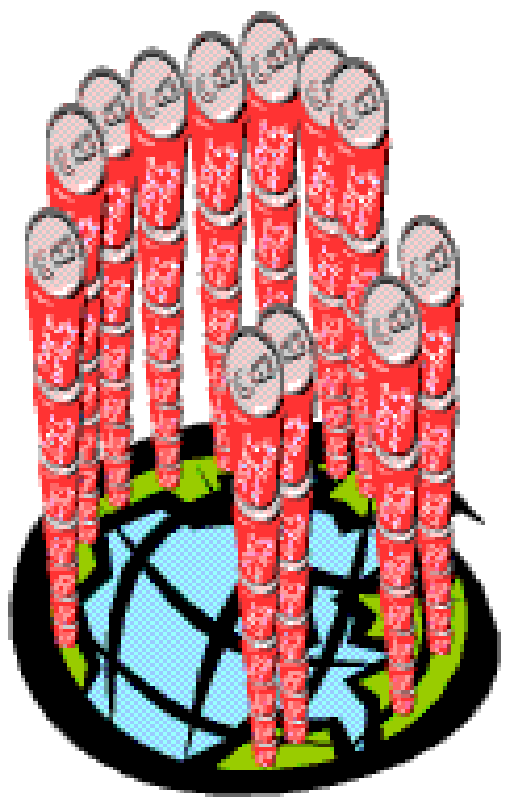
6.02×10^{23}

The Mole

- **A counting unit**
- *602 billion trillion = 602,000,000,000,000,000,000,000 =* **6.02×10^{23}**
- **Named in honor of**

  Amedeo Avogadro (1776 – 1856)
- **6.02×10^{23} particles = 1 mole**

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 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.

Avogadro's Number as Conversion Factor

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

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

or

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

PARTICLES can be:

atoms, formula units, ions *OR* molecules!

A Mole of Particles
Contains 6.02 x 10^{23} particles

1 mole C = 6.02 x 10^{23} C atoms

1 mole H_2O = 6.02 x 10^{23} H_2O molecules

1 mole NaCl = 6.02 x 10^{23} NaCl formula units

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1 NaCl → 1 Na^+ + 1 Cl^-

1 mole NaCl = 1 mole Na^+ ions = 6.02 x 10^{23} Na^+ ions

1 mole NaCl = 1 mole Cl^- ions = 6.02 x 10^{23} Cl^- ions

Conversion Factor change UNITS!

KNOWN x $\frac{\text{CONVERSION}}{\text{FACTOR(s)}}$ = UNKNOWN

Given to me in the problem!

Used to change units one step at a time!

What I need to find!

Learning Check

1. Number of atoms in 0.500 mole of Al

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

3. How many particles are in 1.76 moles of Li?

The Mole

Review Notes 11.2 (pt.1)

6.02×10^{23}

Molar Mass

= mass of 1 mole

- **units:** ***grams/mole***
- **= atomic mass… *in grams*!**
  - **found on the periodic table**

1 mole of C atoms =

1 mole of Mg atoms =

1 mole of Cu atoms =

Mass of 1 mole = sum of atomic masses

1 mole of $CaCl_2$ = ?? g/mol

1 ~~mol~~ Ca x 40.08 $\frac{g}{\cancel{mol}}$ =

2 ~~mol~~ Cl x 35.45 $\frac{g}{\cancel{mol}}$ =

110.98 $\frac{g}{mol}$ $CaCl_2$

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1 mole of N_2O_4 =

For molar mass, ALWAYS use two decimal places!

Learning Check!

A. **Molar Mass** of K_2O = ? g/mol

94.20 g/mol

B. **Molar Mass** of antacid $Al(OH)_3$ = ? g/mol

78.01 g/mol

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.

Molar mass of $C_{17}H_{18}F_3NO$ = 309.36 g/mole

Review Notes 11.2 (pt.2)

Conversions with Molar Mass

Conversions with Molar Mass

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

Known	Unknown
3.00 mol Al	? g Al

Mass A ⟷ *molar mass* ⟷ **Moles A**

1. Molar mass of Al: **1 mole Al = 26.98 g Al**

2. Setup: ***Known x Conv. Factors = Unknown***

$$3.00 \text{ mol Al} \times \frac{26.98 \text{ g Al}}{1 \text{ mol Al}} = \square$$

Learning Check!

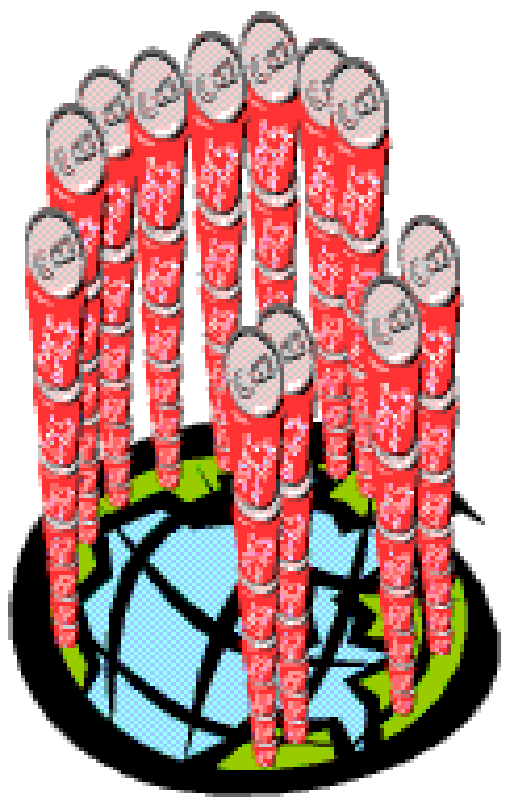
The artificial sweetener aspartame (Nutra-Sweet) formula $C_{14}H_{18}N_2O_5$ is used to sweeten diet foods, coffee and soft drinks. How many moles of aspartame are present in 225 g of aspartame?

Mass A ⟷ ***molar mass*** ⟷ **Moles A**

molar mass = 294.34 g/mol

$$225\ g\ C_{14}H_{18}N_2O_5 \times \frac{1\ mol\ C_{14}H_{18}N_2O_5}{294.34\ g\ C_{14}H_{18}N_2O_5} = 0.764\ mol\ C_{14}H_{18}N_2O_5$$

Just How Big is a Mole?



- **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.**

Review Notes 11.2 (pt.3)

Molar Conversions: *Two steps*

Everything must go through Moles!!!

Molar Conversions: *Two steps*

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

molar mass *Avogadro's #*

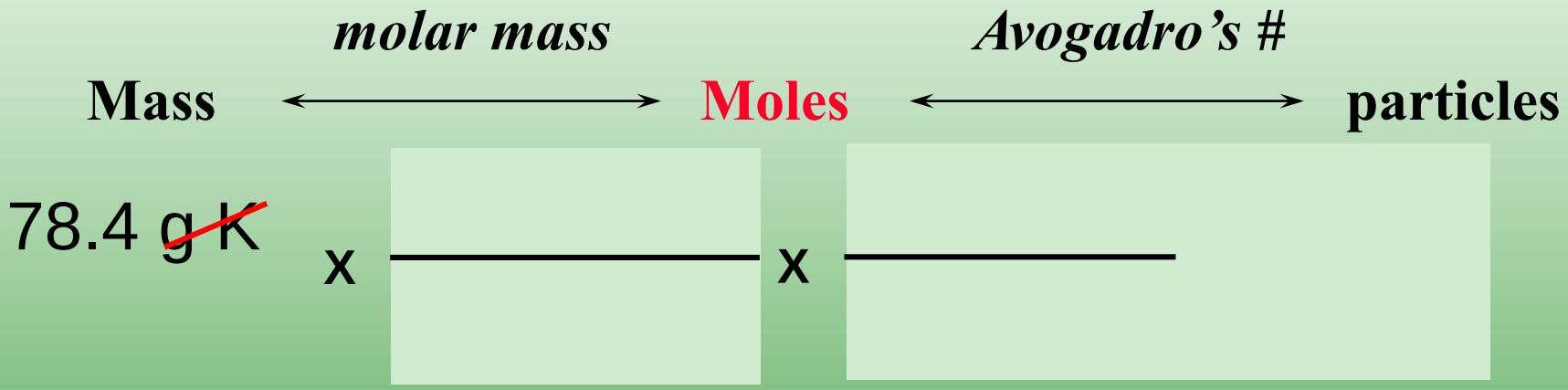
Mass ⟷ **Moles** ⟷ **particles**

35.4 ~~g Cu~~ x _____ x _____

= 3.35 X 10^{23} atoms Cu

Learning Check!

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



= 1.21 X 10^{24} atoms K

Learning Check!

What is the mass (in grams) of

1.20 X 10^{24} molecules of glucose ($C_6H_{12}O_6$)?

Mass	← *molar mass* →	Moles	← *Avogadro's #* →	particles

1.20 X 10^{24} ~~molec $C_6H_{12}O_6$~~ X ——— X ———

= 359 g $C_6H_{12}O_6$

Molar Conversions: 11.3

Breaking down a compound

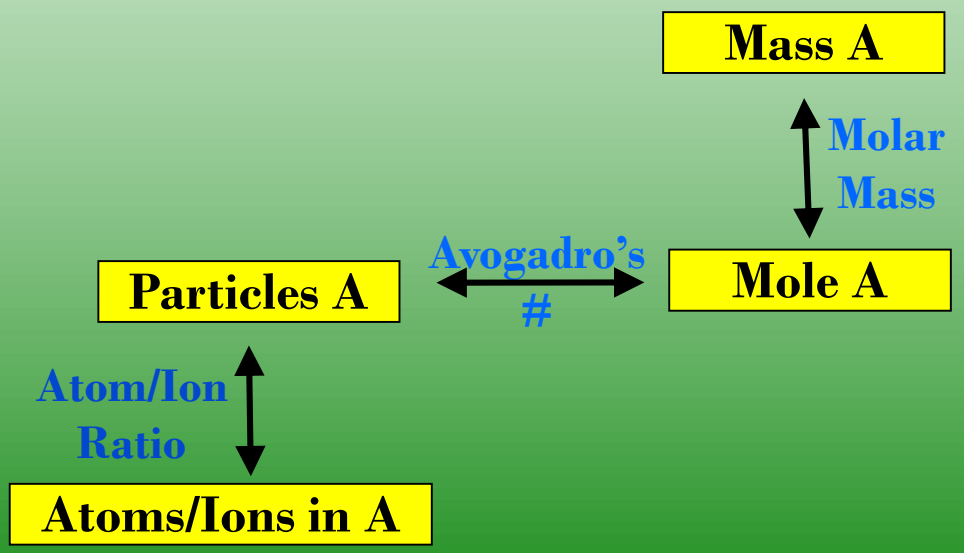
- **ION/ATOM RATIOS**

$NaC_2H_3O_2$

- IONS Ratio:
- 1 f.u. $NaC_2H_3O_2$ = 1Na^+ ion + 1 $C_2H_3O_2^-$ ion

OR

- ATOM ratio:
- 1 f.u. $NaC_2H_3O_2$ = 1 Na atom
  2 C atoms
  3 H atoms
  2 O atoms



Molar Conversions: *Breaking down a compound*

- Determine the number of acetate ions in 3.5 grams of sodium acetate.

$$3.5\ \text{g } NaC_2H_3O_2 \times \frac{1\ \text{mol } NaC_2H_3O_2}{82.04\ \text{g } NaC_2H_3O_2} \times \frac{6.02\times10^{23}\ \text{f.u. } NaC_2H_3O_2}{1\ \text{mol } NaC_2H_3O_2}$$

$$\times \frac{1\ C_2H_3O_2^-\ \text{ion}}{1\ \text{f.u. } NaC_2H_3O_2} = 2.6\times10^{22}\ C_2H_3O_2^-\ \text{ions}$$

Molar Conversions: *Breaking down a compound*

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

Did you remember oxygen is a diatomic molecule (O_2)??

$$78.1\ \text{g}\ O_2 \times \frac{1\ \text{mol}\ O_2}{32.0\ \text{g}\ O_2} \times \frac{6.02 \times 10^{23}\ \text{molecules}\ O_2}{1\ \text{mol}\ O_2} \times \frac{2\ \text{atoms O}}{1\ \text{molecule}\ O_2}$$

$= 2.94 \times 10^{24}$ atoms O

Molar Conversions: 11.3 pt.2

Breaking down a compound

How many mole ratios in $NaC_2H_3O_2$??

1 mole $NaC_2H_3O_2$ = 1 mole Na^+ ions

= 1 mole $C_2H_3O_2^-$ ions

= 1 mole Na atoms

= 2 mole C atoms

= 3 mole H atoms

= 2 mole O atoms

Molar Conversions: *Breaking down a compound*

- Determine the number of moles of acetate ion in 3.5 moles of sodium acetate.

$$3.5 \text{ mol } NaC_2H_3O_2 \times \frac{1 \text{ mol } C_2H_3O_2^-}{1 \text{ mol } NaC_2H_3O_2} = 3.5 \text{ mol } C_2H_3O_2^-$$

- Determine the number of moles of potassium ion in 0.176 moles of potassium phosphate.

$$0.176 \text{ mol } K_3PO_4 \times \frac{3 \text{ mol } K^+}{1 \text{ mol } K_3PO_4} = 0.528 \text{ mol } K^+$$

Review Notes 11.4

Percent Composition

- **Percent by mass of each element in a compound.**

$$\% \text{ by mass} = \frac{\text{Mass of element}}{\text{Mass of compound}} \times 100$$

- **Use given masses from an experiment (**data**).**
- **If no data, use molar masses (**from periodic table!**)**

Percent Composition

What percent of water *is* hydrogen?

Known	Unknown
Water (H_2O)	%H

$$\% \text{ by mass} = \frac{\text{Mass of element}}{\text{Mass of compound}} \times 100$$

$$\frac{2.02\text{g H}}{18.02\text{g } H_2O} \times 100 = 11.21\%$$

Percent Composition

Calculate the percent composition of table salt.

Known	Unknown
Table Salt (NaCl)	%Na
	%Cl

$$\% \text{ by mass} = \frac{\text{Mass of element}}{\text{Mass of compound}} \times 100$$

$$\frac{22.99\text{g Na}}{58.44\text{g NaCl}} \times 100 = 39.34\%$$

$$\frac{35.45\text{g Cl}}{58.44\text{g NaCl}} \times 100 = 60.66\%$$

$$100.00\%$$

Percent Composition

A compound has 30.33% chlorine and the rest is sodium. Is this table salt?

Table salt has is sodium and chlorine!

…but is has 60.66% Cl

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?

$$\frac{60.05\text{g C}}{146.14\text{g } C_5H_8NO_4} \times 100 = 41.09\%\ \text{C}$$

Types of Formulas

- **Empirical Formula**
  - ***Smallest ratio* of atoms.**
  - ***Ionic formula are empirical formulas!***
- **Molecular Formula**
  - ***Actual* number of atoms in *one molecule***
  - **Not reduced!**