The Mole

I. Molar Conversions

C. Johannesson

A. What is the Mole?

- A counting number (like a dozen)
- Avogadro's number (N_A)
- 1 mol = 6.02×10^{23} items

A **VERY** large amount!!!!

HOW LARGE IS IT???

- 1 mole of hockey pucks would equal the mass of the moon!

- 1 mole of basketballs would fill a bag the size of the earth!

- 1 mole of pennies would cover the Earth 1/4 mile deep!

B. Molar Mass

- Mass of 1 mole of an element or compound.
- Atomic mass tells the...
  - atomic mass units per atom (amu)
  - grams per mole (g/mol)
- Round to 2 decimal places

B. Molar Mass Examples

- carbon — 12.01 g/mol
- aluminum — 26.98 g/mol
- zinc — 65.39 g/mol

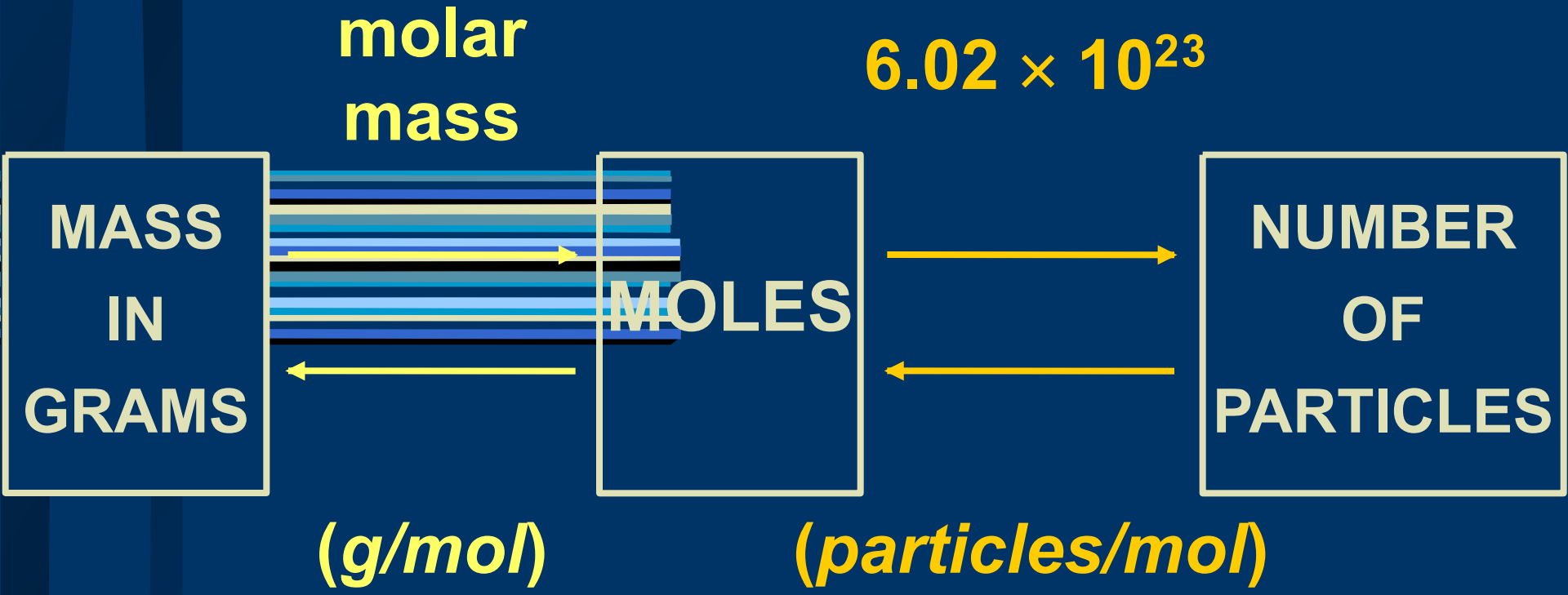
B. Molar Mass Examples

- water
  - H_2O
  - 2(1.01) + 16.00 = 18.02 g/mol
- sodium chloride
  - NaCl
  - 22.99 + 35.45 = 58.44 g/mol

B. Molar Mass Examples

- sodium bicarbonate
  - $NaHCO_3$
  - 22.99 + 1.01 + 12.01 + 3(16.00) = 84.01 g/mol
- sucrose
  - $C_{12}H_{22}O_{11}$
  - 12(12.01) + 22(1.01) + 11(16.00) = 342.34 g/mol

C. Molar Conversions



C. Molar Conversion Examples

- How many moles of carbon are in 26 g of carbon?

$$\frac{26\ \text{g C} \mid 1\ \text{mol C}}{12.01\ \text{g C}} = 2.2\ \text{mol C}$$

C. Molar Conversion Examples

- How many molecules are in 2.50 moles of $C_{12}H_{22}O_{11}$?

$$\frac{2.50 \text{ mol} \mid 6.02 \times 10^{23} \text{ molecules}}{\mid 1 \text{ mol}} = 1.51 \times 10^{24} \text{ molecules } C_{12}H_{22}O_{11}$$

C. Molar Conversion Examples

- Find the mass of 2.1×10^{24} molecules of $NaHCO_3$.

$$\frac{2.1 \times 10^{24}\ \text{molecules}}{} \times \frac{1\ \text{mol}}{6.02 \times 10^{23}\ \text{molecules}} \times \frac{84.01\ \text{g}}{1\ \text{mol}}$$

$$= 290\ \text{g}\ NaHCO_3$$

The Mole

II. Molarity

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I II III IV

A. Molarity

- Concentration of a solution.

substance being dissolved

$$Molarity\ (M) = \frac{moles\ of\ solute}{liters\ of\ solution}$$

total combined volume

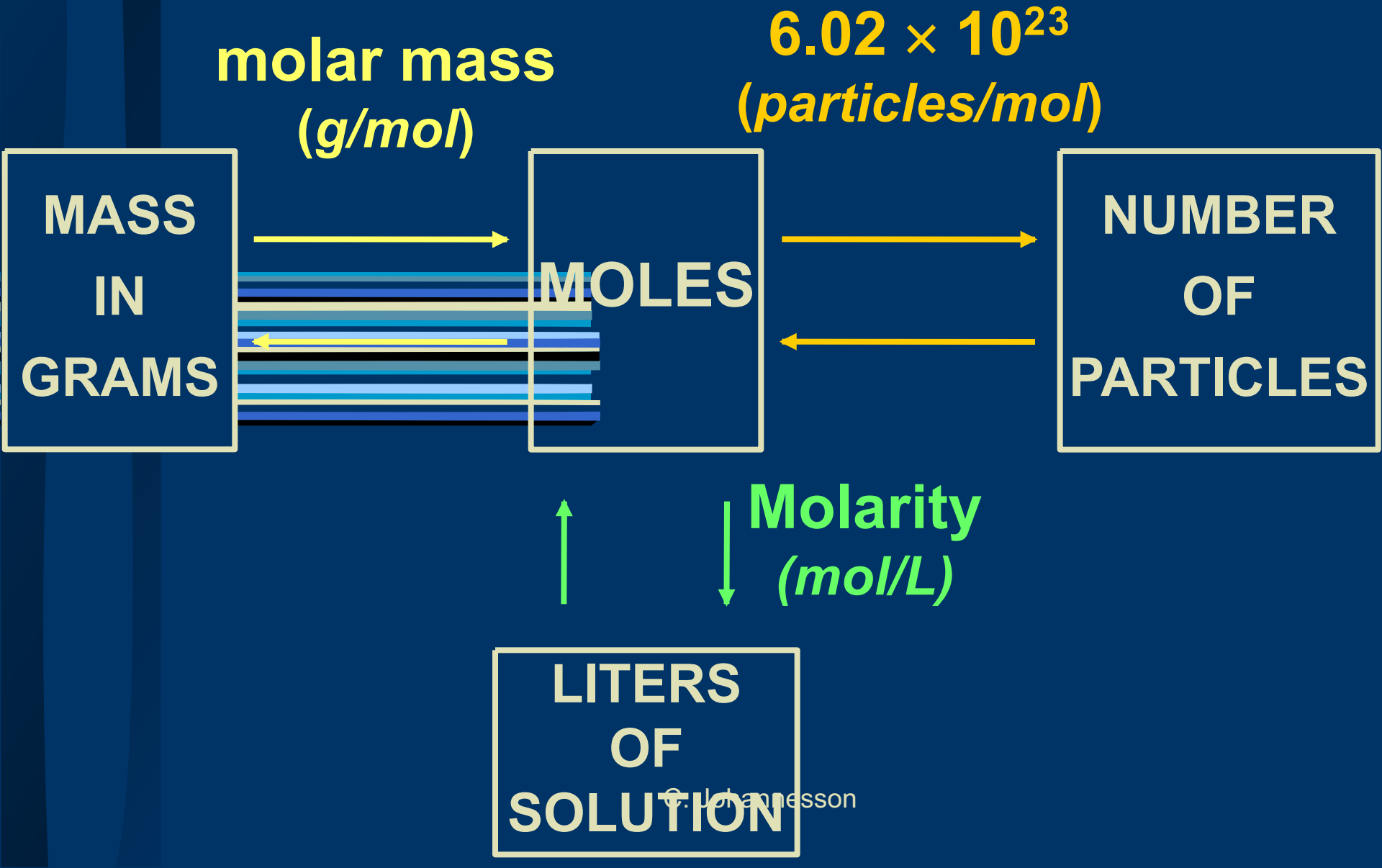
A. Molarity

2M HCl What does this mean?

$$M = \frac{mol}{L}$$

$$2M\ HCl = \frac{2\ mol\ HCl}{1\ L}$$

B. Molarity Calculations



B. Molarity Calculations

- How many grams of NaCl are required to make 0.500L of 0.25*M* NaCl?

$$0.500\ \cancel{L} \times \frac{0.25\ \cancel{mol}}{1\ \cancel{L}} \times \frac{58.44\ g}{1\ \cancel{mol}}$$

$$0.25M = \frac{0.25\ mol}{1\ L}$$

= 7.3 g NaCl

B. Molarity Calculations

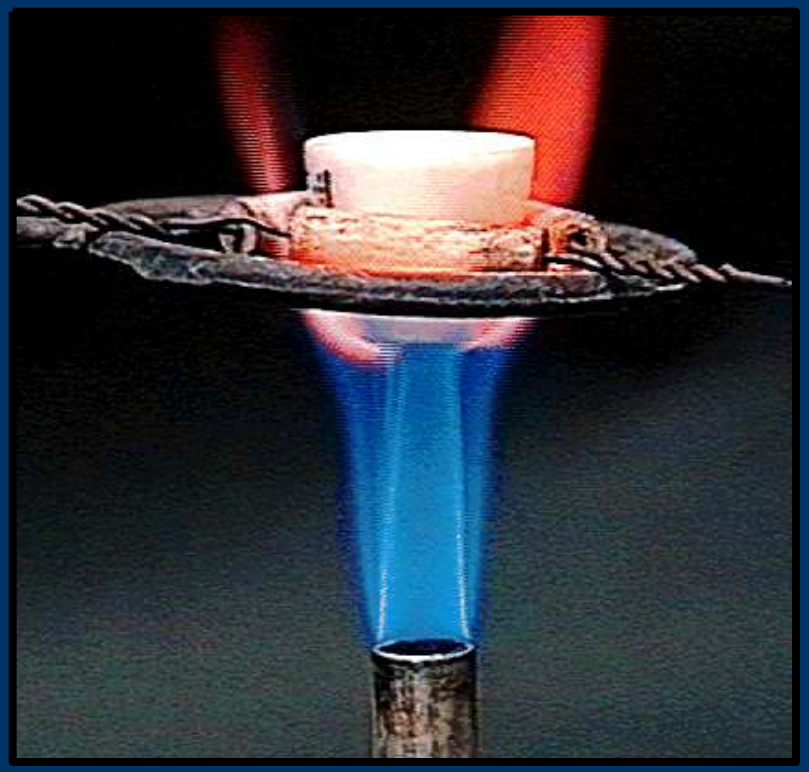
- Find the molarity of a 250 mL solution containing 10.0 g of NaF.

$$\frac{10.0\ \text{g}}{41.99\ \text{g}} \times \frac{1\ \text{mol}}{} = 0.238\ \text{mol NaF}$$

$$M = \frac{mol}{L}$$

$$M = \frac{0.238\ \text{mol}}{0.25\ \text{L}} = 0.95M\ \text{NaF}$$

The Mole



III. Formula Calculations

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I II III IV

A. Percentage Composition

- the percentage by mass of each element in a compound

$$\%\,composition = \frac{mass\ of\ element}{total\ mass} \times 100$$

A. Percentage Composition

- Find the % composition of Cu_2S.

$$\%Cu = \frac{127.10\ g\ Cu}{159.17\ g\ Cu_2S} \times 100 = 79.852\%\ Cu$$

$$\%S = \frac{32.07\ g\ S}{159.17\ g\ Cu_2S} \times 100 = 20.15\%\ S$$

A. Percentage Composition

- Find the percentage composition of a sample that is 28 g Fe and 8.0 g O.

$$\%Fe = \frac{28\ g}{36\ g} \times 100 = 78\%\ Fe$$

$$\%O = \frac{8.0\ g}{36\ g} \times 100 = 22\%\ O$$

A. Percentage Composition

- How many grams of copper are in a 38.0-gram sample of Cu_2S?

Cu_2S is 79.852% Cu

(38.0 g Cu_2S)(0.79852) = 30.3 g Cu

A. Percentage Composition

- Find the mass percentage of water in calcium chloride dihydrate, $CaCl_2 \cdot 2H_2O$?

$$\%H_2O = \frac{36.04\ g}{147.02\ g} \times 100 = 24.51\%\ H_2O$$

B. Empirical Formula

- Smallest whole number ratio of atoms in a compound

C_2H_6

reduce subscripts

CH_3

B. Empirical Formula

1. Find mass (or %) of each element.
2. Find moles of each element.
3. Divide moles by the smallest # to find subscripts.
4. When necessary, multiply subscripts by 2, 3, or 4 to get whole #'s.

B. Empirical Formula

- Find the empirical formula for a sample of 25.9% N and 74.1% O.

$$\frac{25.9\ \text{g}}{14.01\ \text{g}} \left| \frac{1\ \text{mol}}{} \right. = \frac{1.85\ \text{mol N}}{1.85\ \text{mol}} = 1\ \text{N}$$

$$\frac{74.1\ \text{g}}{16.00\ \text{g}} \left| \frac{1\ \text{mol}}{} \right. = \frac{4.63\ \text{mol O}}{1.85\ \text{mol}} = 2.5\ \text{O}$$

B. Empirical Formula

$N_1O_{2.5}$

Need to make the subscripts whole numbers $\Rightarrow$ multiply by 2

N_2O_5

C. Molecular Formula

- "True Formula" - the actual number of atoms in a compound

empirical formula

CH_3

?

molecular formula

C_2H_6

C. Molecular Formula

1. Find the empirical formula.
2. Find the empirical formula mass.
3. Divide the molecular mass by the empirical mass.
4. Multiply each subscript by the answer from step 3.

$$\frac{MF\ mass}{EF\ mass} = n$$

$$(EF)_n$$

C. Molecular Formula

- The empirical formula for ethylene is CH_2. Find the molecular formula if the molecular mass is 28.1 g/mol?

empirical mass = 14.03 g/mol

$$\frac{28.1 \text{ g/mol}}{14.03 \text{ g/mol}} = 2.00$$

$$(CH_2)_2 \Longrightarrow C_2H_4$$