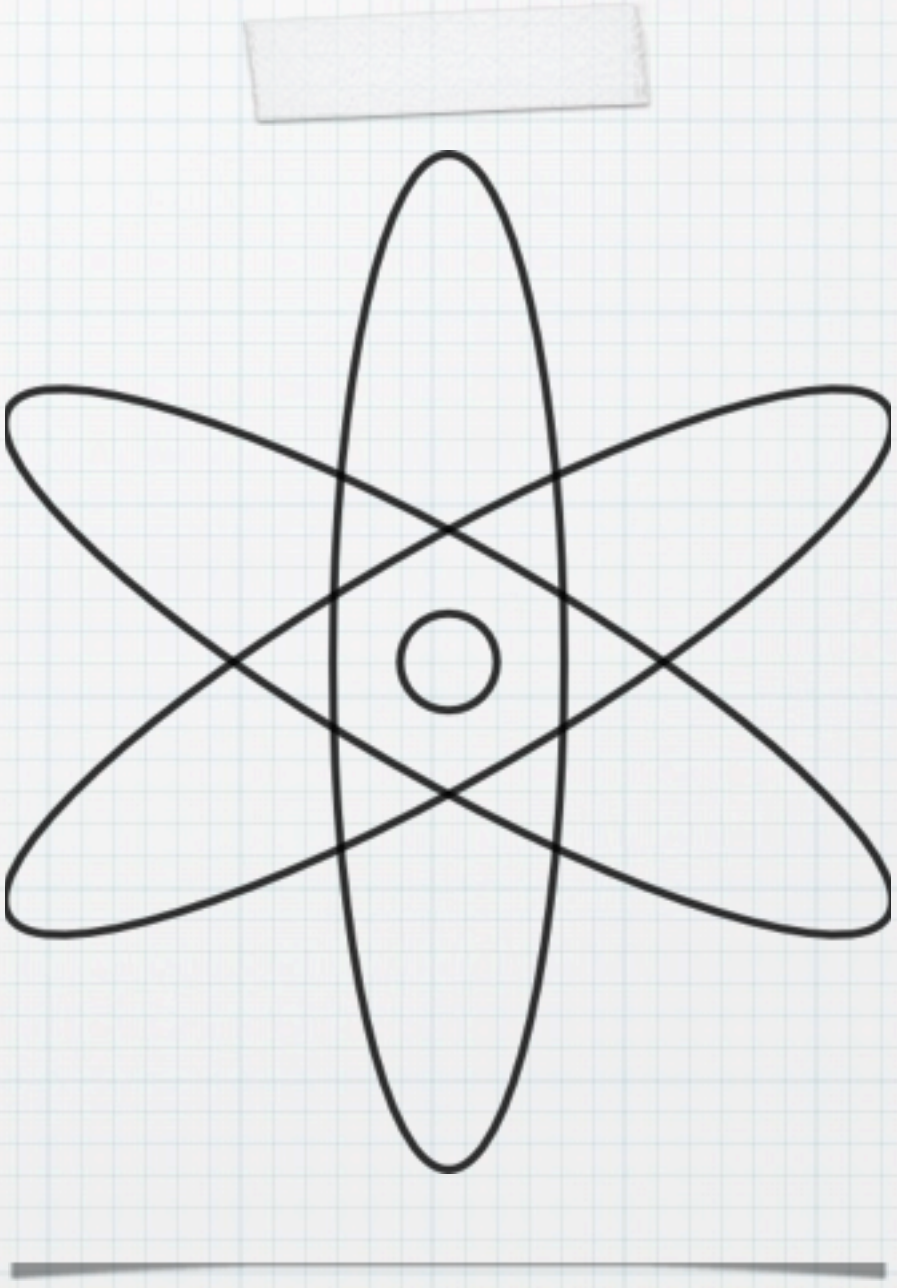
Molar Mass and the Mole

An Introduction to Calculating Chemical Reactions . . .

Counting Atoms

* The mass of a single atom, or even molecule is incredibly small. So small, that using the mass of a single atom has little purpose in real world applications.



Counting Atoms

* In 1811, Amedeo Avagradro determined that any convenient quantity of matter must contain an enormous number of atoms, ion, molecules, ect.

Counting Atoms

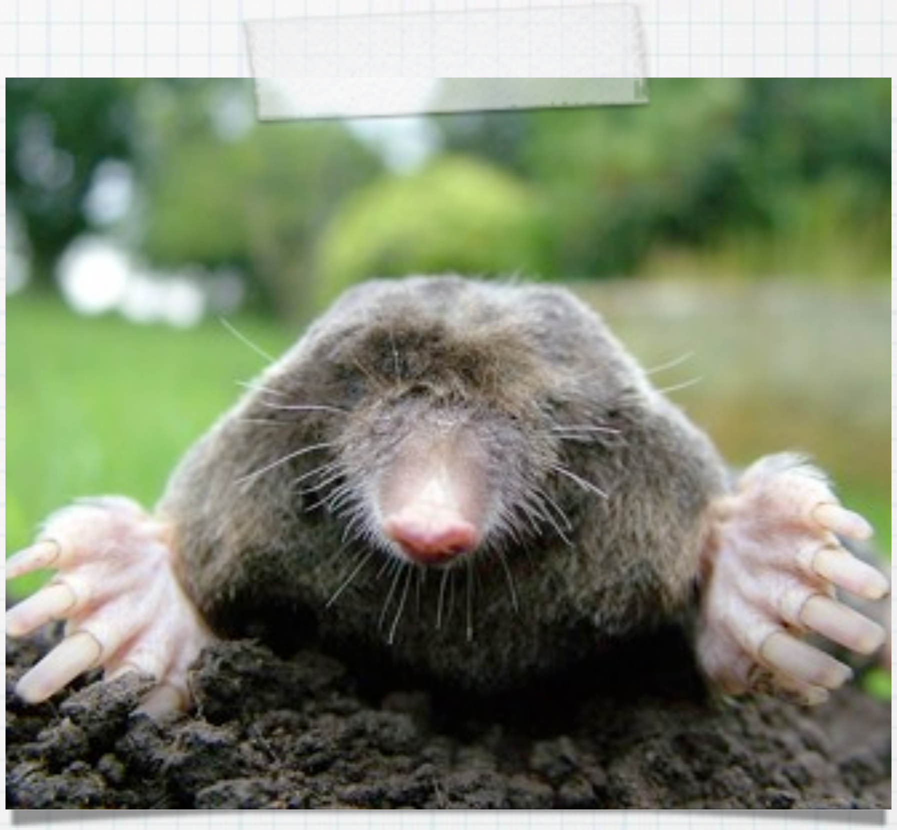
* Joeself Loschmidt estimated that 2.68 x 10^{25} is a convenient and measurable number of entities to deal with in chemistry.

Counting Atoms

* Using carbon as an example, it has been showed that 6.023 x 10^{23} atoms of carbon has a mass of 12.01. This number was signifigant as that is the numerical value of the atoms mass.

Mole

* Mole: Used to measure the amount of a substance; conatins as many particles as exactly 12g of carbon-12.



Representative Particles for Elements and Compounds:

-Particle for pure monoatomic elements(Na) are atoms.

-Particle for diatomic molecules (O_2) and compounds (H_2O) are molecules

-Particles for pure ionic compounds (NaI) are formula units

Avagadro's Constant

* Avagadro's Constant: The number of particles in one mole of a substance; a value that is equal to 6.02×10^{23} particles.

Example

* A mole is just a quick way of summarizing large quantities.

A pair giraffes:

A dozen giraffes

A mole (6.02×10^{23}) of giraffes

. . . . nevermind

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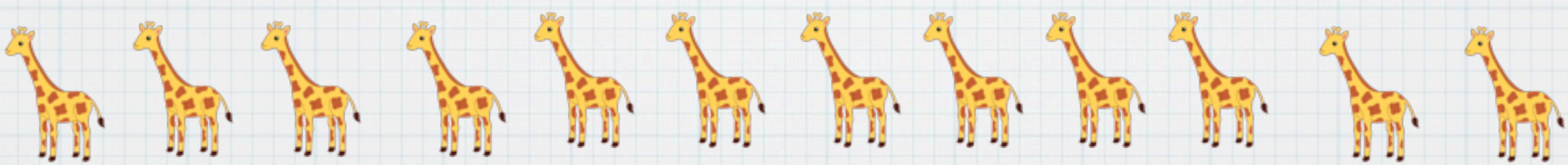


A mole (6.02×10^{23}) of giraffes

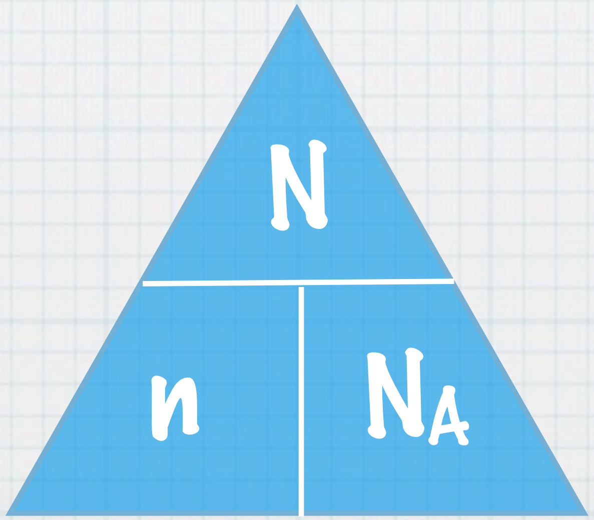
. . . . nevermind

Using Avagadro's Constant

- The relationship between moles, individual particle and Avagardro's constant can be expressed as:

$$n = \frac{N}{N_A}$$

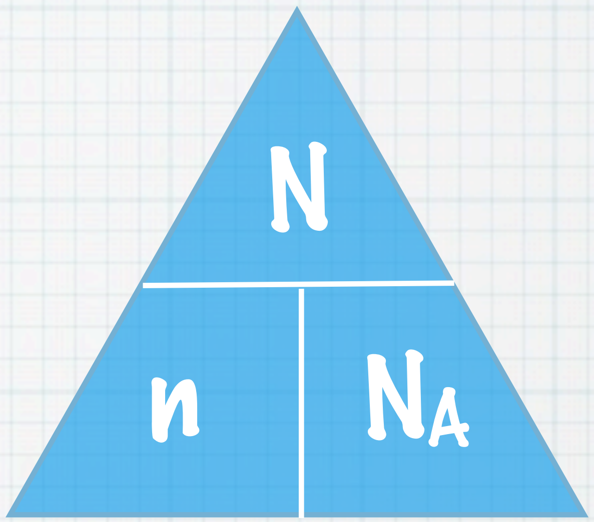
n= number of moles
N= number of particles
N_A= Avagadro's constant



Example

* Determine the number of particles in 1.87 moles of butane gas, C_4H_{10}.
  * Given: n= 1.87 mol
  * Given: N_A= 6.02 x 10^{23}
  * Required: N

Example



$N = n \times N_A$

$$N = 1.87 \text{ mol} \times \frac{6.02 \times 10^{23} \text{ molecules}}{\text{mol}}$$

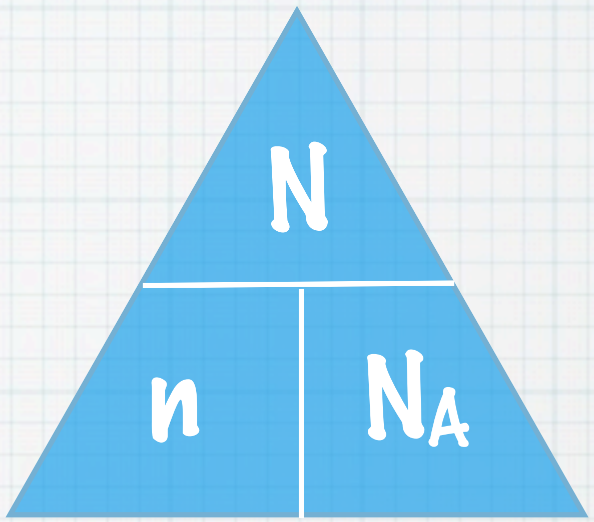
$N = 1.13 \times 10^{24}$ molecules

Therefore there are 1.13 molecules in 1.87 moles of butane gas.

Example

- Determine the number of particles in 4.98 moles of sodium chloride.
  - Given: n= 4.98 mol
  - Given: N_A= 6.02 x 10^{23}
  - Required: N

Example



$N = n \times N_A$

$$N = 4.98 \text{ mol} \times \frac{6.02 \times 10^{23} \text{ formula units}}{\text{mol}}$$

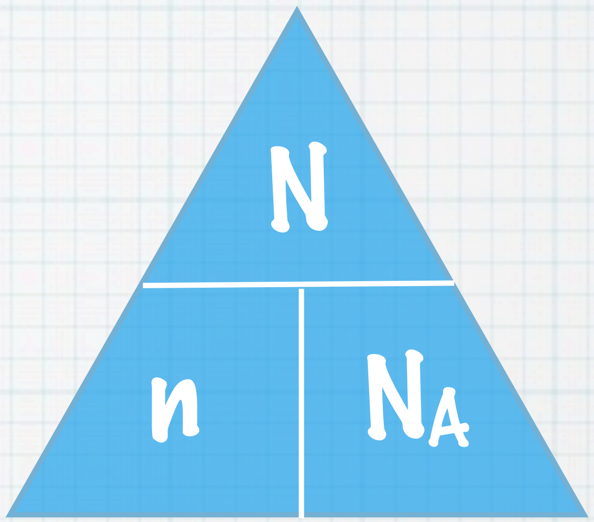
$N = 3.00 \times 10^{24}$ formula units

Therefore there are 3.00 formula units in 4.98 moles of sodium chloride.

Example

* If you have 1.37×10^{22} iron atoms, how many moles of iron do you have?
  * Given: $N = 1.37 \times 10^{22}$
  * Given: $N_A = 6.02 \times 10^{23}$
  * Required: n

Example



$n = N/N_A$

$$n = \frac{1.38 \times 10^{22} \text{ atoms of iron}}{6.02 \times 10^{23} \text{ atoms/mol}}$$

N= 0.02 moles of iron

Therefore there are 0.02 moles of iron.

Homework

* Solve each of the following problems. Be sure to show all of your work and express the final answer with the correct number of significant digits.
* How many moles are there in:
    * 1.50×10^{22} atoms of Ar?
    * 4.60 g of Na?
* Calculate the number of moles of SO_2 present in 3.01×10^{23} molecules of the gas
    * Calculate the number of atoms of sulfur present in the same sample of SO_2
    * Calculate the number of moles of oxygen atoms present in the same sample.
* If exactly four moles of an element have a mass of 124 g, what would the mass of a single mole of the element be? Identify the element.
* How many formula units are present in 119.0 g of potassium bromide?
* How many atoms of iron are there in 167.4 g of iron?

Atomic Mass

* **Atomic Mass**: The mass of one atom of an element
    * Expressed in atomic mass units, u
* Found on the periodic table
* Eg, Atomic Mass of hydrogen is u=1.00, atomic mass of copper is u=63.55

Molecular Mass

* **Molar Mass(M):** Mass of one mole of a substance.
* One mole of any element has a mass that is equal to the element's mass expressed in grams.

Atomic Molar Mass

* Atomic molar mass: mss of one mole of any atom on the periodic table.
    * Units are g/mol.

Example

- What would the atomic molar mass of calcium be?

Example

* From the periodic table we know that calcium has a mass of 40.08. So the atomic molar mass of calcium would be 40.08 g/mol.

Molecular Molar Mass

* Molecular Molar Mass: The mass of one mole of molecules of a substance.
  * Units are g/mol.

Example

* What would the molecular molar mass of carbon dioxide be?

Example

* What would the molecular molar mass of carbon dioxide be?
  * $M_{CO_2} = M_C + 2M_O$
  * M_{CO_2} = (12.01 g/mol) + 2(16.00g/mol)
  * M_{CO_2} = 44.01 g/mol
  * Therefore the molar mass of carbon dioxide is 44.01 g/mol

Formula Unit Molar Mass

* Formula Unit Molar Mass: The mass of one mole of formula units of a substance.
* Units are g/mol

Example

* What would the molecular molar mass of calcium iodide be?
  * $M_{CaI_2} = M_{Ca} + 2M_I$
  * M_{CaI_2} = (40.08 g/mol) + 2(126. 90 g/mol)
  * M_{CaI_2} = 293.88 g/mol
  * Therefore the molar mass of calcium iodide is 293.88 g/mol

Linking Molar Mass and Moles

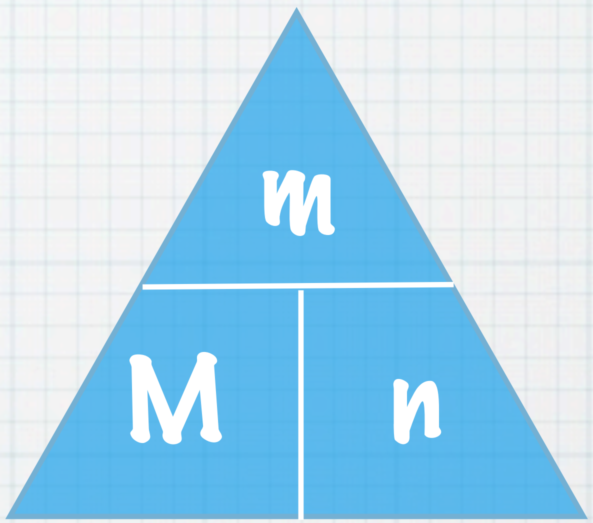
* We know that molar mass represents the mass in grams per mole of substance (g/mol)

* Therefore, M= m/n

    * Where M= molar mass

    * Where m = mass

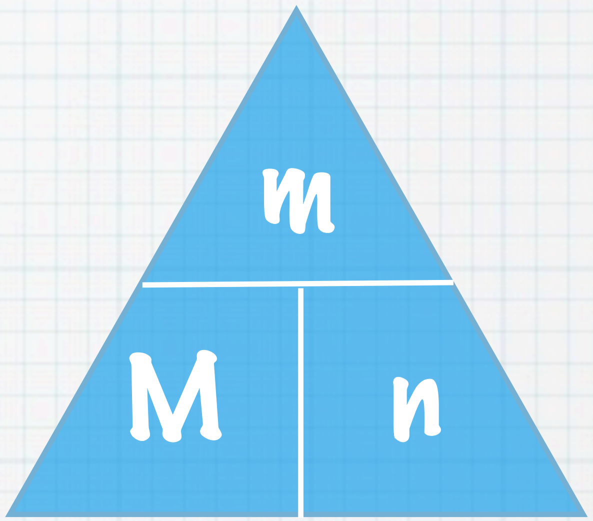
    * Where n= number of moles



Example

* What is the mass of 2.0 moles of Na?
* Given: n= 2.0 moles
* Given: M=23.00 g/mol
* Required: m

Example



* $m = n \times M$

$$m = 2.0 \text{ mols} \times \frac{23 \text{ g}}{\text{mol}}$$

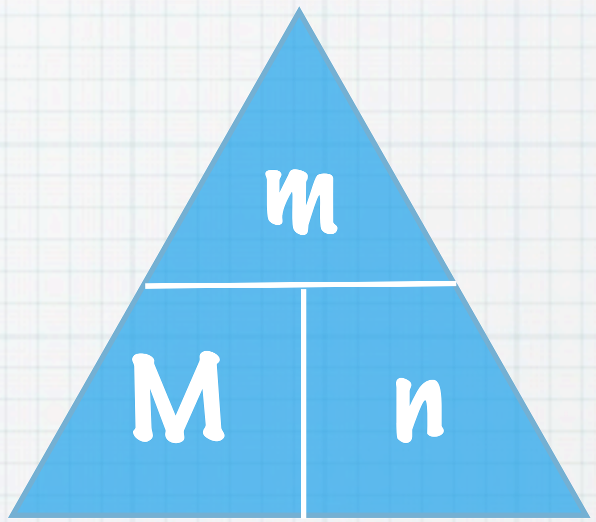
Therefore the mass of 2.0 mols of Na is 46 grams.

Example

* How many moles are in 57.5 g of NaCl?
* Given: m=57.5g
* Given: M=58.4 g/mol
* Required: n

Example

* n = m / M



$$n = \frac{57.5\ g}{58.4\ g/mol}$$

n= 0.98 mols

Therefore their are 0.98 mols of NaCl in a 57.5 g sample.

Calculating the Number of Atoms From Mass

- How to calculate number of atoms from mass

- 1) Step 1: Calculate the number of moles using $n = m / M$

- 2) Step 2: Calculate the number of atoms using $N = n \times N_A$

Example

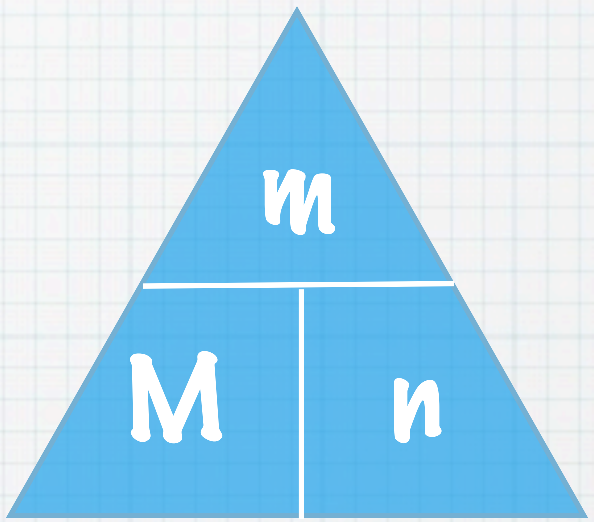
* Calculate the number of atoms of gold in a 275.8g nugget of pure gold.
* Given: m=275.8 g
* Given: M= 196.97
* Given: N_A= 6.02 x 10^{23}
* Required: N

Step 1

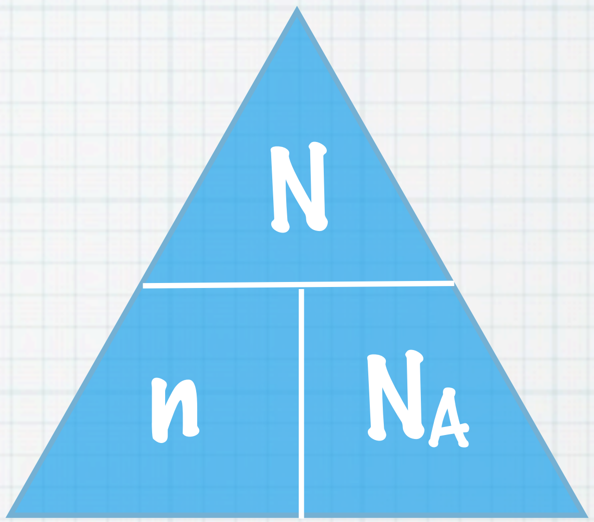
- $n = m / M$

$$n = \frac{275.8\ g}{196.97\ g/mol}$$

$n = 1.40$ mols



Step 2



$N = n \times N_A$

$$N = 1.40 \text{ mol} \times \frac{6.02 \times 10^{23} \text{ atoms}}{\text{mol}}$$

$N = 8.43 \times 10^{23}$ atoms

Therefore there are 8.43×10^{23} atoms of gold in one nugget that weighs 275.8g.

Homework

* p. 237 # 41-44
* p. 239 # 51-54
* p. 242 # 61, 62