RELATING MASS TO ATOMS
The relative mass makes it possible to know how many atoms of an element are present in a sample of the element with a measurable mass.

Three very important concepts provide the basis for relating mass in grams to number of atoms:

1. The mole
2. Avogadro’s number
3. Molar mass
The Mole Concept by TED-Ed

(https://www.youtube.com/watch?v=TEl4jeETVmg)
**The Mole**

- **Mole**: the amount of substance that contains as many particles as there are atoms in exactly 12 g of carbon-12
  - SI unit for the amount of substance
  - A counting unit
  - Experimentally determined value

- 1 mole of substance = \(6.022 \times 10^{23}\) atoms

- 1 mole of substance = the atomic mass of substance in grams
Avogadro’s number: 6.022x10^{23} – the number of particles in exactly one mole of a pure substance

- Named for the 19th century Italian scientist Amedeo Avogadro
  - His ideas were crucial in explaining the relationship between mass and the number of atoms
Remembering Avogadro’s Number:
The Mole Song “A Mole Is A Unit”
Molar mass: the mass of one mole of a pure substance

- Written in units of g/mol

1 molar mass = 1 mole of atoms

1 molar mass of a substance = atomic mass of a substance in grams

- Ex 1: What is the molar mass of carbon?
  - 12.01 g/mol

- Ex 2: What is the molar mass of nickel?
  - 58.69 g/mol
Mass of element in grams

$= \text{Molar Mass} \times \frac{\text{Amount of element in moles}}{\text{Molar Mass}}$

$= \frac{\text{Molar Mass}}{\text{Molar Mass}}$ 

$= \frac{6.022 \times 10^{23}}{6.022 \times 10^{23}}$

Number of atoms of element
Sample Problem (Mole $\rightarrow$ Mass)

- What is the mass in grams of 3.50 mol of the element copper, Cu?
  - **Given**: 3.50 mol Cu
  - **Unknown**: mass of Cu in grams
  - **Compute**:
    1. Find the molar mass of copper in the periodic table
      - 63.55 g/mol
    2. Use appropriate conversion factor to solve
      $$\frac{3.50 \text{ mol Cu}}{1 \text{ mol Cu}} \times 63.55 \text{ g Cu} = 222 \text{ g Cu}$$
1. What is the mass in grams of 2.25 mol of the element iron, Fe?
   ➤ 126 g Fe

2. What is the mass in grams of 0.375 mol of the element potassium, K?
   ➤ 14.7 g K

3. What is the mass in grams of 0.0135 mol of the element sodium, Na?
   ➤ 0.310 g Na
Sample Problem (Mass $\rightarrow$ Moles)

- A chemist produced 11.9 g of aluminum, Al. How many moles of aluminum were produced?
  - **Given**: 11.9 g Al
  - **Unknown**: amount of Al in moles
  - **Compute**:
    - 1. Find the molar mass of aluminum from the periodic table
      - 26.98 g/mol
    - 2. Use appropriate conversion factor to solve
      \[
      \frac{11.9 \text{ g Al}}{26.98 \text{ g Al}} = 0.441 \text{ mol Al}
      \]
1. How many moles of calcium, Ca, are in 5.00 g of calcium?

\[ \text{Answer: 0.125 mol Ca} \]
Conversions with Avogadro’s Number

- Avogadro’s number can be used to find the number of atoms of an element from the amount in moles.
- It can also be used to find the amount of an element in moles from the number of atoms.
Sample Problem (Moles \(\rightarrow\) Atoms)

- Determine the number of atoms in 2.0 mol of calcium, Ca.
  - **Given:** 2.0 mol Ca
  - **Unknown:** Amount of atoms of Ca
  - **Compute:**
    - *Remember:* 1 mol of substance = \(6.022 \times 10^{23}\) atoms
    
    \[
    \begin{array}{ccc}
    \text{2.00 mol Ca} & \times & \frac{6.022 \times 10^{23} \text{ atoms Ca}}{1 \text{ mol Ca}} \\
    \hline
    \end{array}
    \]
    
    \(= 1.20 \times 10^{24}\) atoms Ca
1. How many atoms of zinc, Zn, are in 2.50 mol of zinc?
   \[ 1.50 \times 10^{24} \text{ atoms Zn} \]

2. How many atoms of sodium, Na, are in 3.80 mol of sodium?
   \[ 2.29 \times 10^{24} \text{ atoms Na} \]

3. How many atoms of aluminum, Al, are in 2.75 mol of aluminum?
   \[ 1.66 \times 10^{24} \text{ atoms Al} \]
**Sample Problem (Mass → Atoms)**

How many atoms of sulfur, S, are in 4.00 g of sulfur?

- **Given:** 4.00 g S
- **Unknown:** amount of atoms of sulfur
- **Compute:**
  1. Always start off with what is given
  2. Know what units need to be cancelled out
  3. Determine the molar mass of the element by looking on the periodic table
  4. *Remember:* 1 mole of substance = 6.022 x 10^{23} atoms

\[
\begin{align*}
4.00 \text{ g S} & \quad \text{1 mol S} \quad \text{6.022 x 10}^{23} \text{ atoms S} \\
32.07 \text{ g S} & \quad \text{1 mol S} \quad \text{= 7.51 x 10}^{22} \text{ atoms S}
\end{align*}
\]
1. How many atoms of carbon, C, are in 1.50 g of carbon?
   - $7.52 \times 10^{22}$ atoms C

2. How many atoms of silicon, Si, are in 7.02 g of silicon?
   - $1.50 \times 10^{23}$ atoms Si
Practice

1. How many atoms are present in 52.3 g of mercury?
2. Determine the amount in moles of 15.1 g of titanium.
3. Calculate the mass in grams of 0.345 moles of gallium.
4. What is the amount atoms in 0.52 moles of vanadium?
5. Determine the number of atoms of 18.2 g of sulfur.