Atoms are extremely small

- Visible samples of elements contain an enormous number of individual atoms.
- To represent this large number, chemists created a new unit called…
  - **The MOLE (mol)!!!**

The mole is a unit!

- Other units…

<table>
<thead>
<tr>
<th>Unit</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Dozen</td>
<td>12 Objects</td>
</tr>
<tr>
<td>1 Ton</td>
<td>2000 lbs.</td>
</tr>
<tr>
<td>1 Hour</td>
<td>60 Minutes</td>
</tr>
</tbody>
</table>

So how many are in a mole?

- Defined by the number of atoms in exactly 12 grams of carbon-12.
- How many is that?
  - $6.022 \times 10^{23}$, or…
  - 602,213,670,000,000,000,000,000 atoms
Moles can be used as conversion factors...
- 1 mol = 6.022 × 10^23

Conversion Factors...
- 1 mol = 6.022×10^23 atoms
- 1 mol = 6.022×10^23 ions
- 1 mol = 6.022×10^23 compounds
- 1 mol = 6.022×10^23 electrons
- 1 mol = 6.022×10^23 bonds

Making Conversions
- How many atoms are in 2.5 moles of Carbon? (Moles → Atoms)
  - Known: 1 mol = 6.022×10^23 atoms
  - \[
  \frac{2.5 \text{ mol}}{1 \text{ mol}} \times \frac{6.022 \times 10^{23} \text{ atoms}}{1 \text{ mol}} = 1.5 \times 10^{24} \text{ atoms}
  \]
- How many molecules are in 20.01 moles of NH₃? (Moles → Molecules)
  - Known: 1 mol = 6.022×10^23 molecules
  - \[
  \frac{20.01 \text{ mol}}{1 \text{ mol}} \times \frac{6.022 \times 10^{23} \text{ molecules}}{1 \text{ mol}} = 1.210 \times 10^{25} \text{ molecules}
  \]

More Conversions
- How many moles are in 12.55 × 10^{24} molecules of water?
- Molecules → Moles
  - Known: 1 mol = 6.022×10^23 molecules
  - \[
  \frac{12.55 \times 10^{24} \text{ molecules}}{1 \text{ mol}} \times \frac{1 \text{ mol}}{6.022 \times 10^{23} \text{ molecules}} = 20.84 \text{ mol of H}_2\text{O}
  \]
- How many moles are in 2.54 × 10^{24} atoms of iron?
- Atoms → Moles
  - Known: 1 mol = 6.022×10^23 atoms
  - \[
  \frac{2.54 \times 10^{24} \text{ atoms}}{1 \text{ mol}} \times \frac{1 \text{ mol}}{6.022 \times 10^{23} \text{ atoms}} = 4.22 \text{ mol of Fe}
  \]
Incorporating Mass (in grams)

- **Molar Mass** – The mass of 1 mole
- 1 mole of an element is equal to its atomic mass in grams.
  - Identify the Molar Mass of C.
    - 12.011 g/mol of C
    - 1 mole of carbon = 12.011 g
    - This is now a conversion factor
  - Identify the Molar Mass of O
    - 15.999 g/mol of O
    - 1 mole of oxygen = 15.999 g

Calculating the Molar Mass of Molecules

- What is the molar mass of water?
  - One mole of water (H₂O) is equal to 18.015 g.
  - Mass of Hydrogen (2 atoms @ 1.0079 g = 2.0158 g)
  - Mass of Oxygen (1 atom @ 15.999 g = 15.999 g)
  - 18.0148 g/mol of H₂O

- What’s the molar mass of CO₂?

Convert to Moles

- How many moles of Hg are found in 80.0 g of Mercury?
  - Grams → Moles
    - Molar Mass: 1 mole of Hg = 200.59 g
    - \( \frac{80.0 \text{ g}}{1} \times \frac{1 \text{ mol}}{200.59 \text{ g}} = 0.399 \text{ mol of Hg} \)

- How many moles of PCl₃ are found in 67.9 g of PCl₃?
  - Grams → Moles
    - Molar Mass: 1 mole of PCl₃ = 137.333 g
    - \( \frac{67.9 \text{ g}}{1} \times \frac{1 \text{ mol}}{137.333 \text{ g}} = 0.494 \text{ mol of PCl₃} \)
Convert to grams
- Identify the mass (in grams) of 17.17 moles of Fe.
  - Moles → Grams
    - Molar Mass: 1 mole of Fe = 55.845 g
    - \[ \frac{17.17 \text{ mol}}{1} \times \frac{55.845 \text{ g}}{1} = 958.8 \text{ g of Fe} \]

- Identify the mass (in grams) of 4.25 moles of NaCl.
  - Moles → Grams
    - Molar Mass: 1 mole of NaCl = 58.443 g
    - \[ \frac{4.25 \text{ mol}}{1} \times \frac{58.443 \text{ g}}{1} = 248 \text{ g of NaCl} \]

One final question
- How many molecules of FeO are there in 400.0 g of FeO?
  - Grams → Molecules
  - Grams → Moles → Molecules
    - Part 1: Grams → Moles
    - Part 2: Moles → Molecules
      - Known: 1 mole of FeO = 71.844 g
      - Known: 1 mol = 6.022 \times 10^{23} \text{ molecules}
      - \[ \frac{400.0 \text{ g}}{1} \times \frac{1 \text{ mol}}{71.844 \text{ g}} \times \frac{6.022 \times 10^{23} \text{ molecules}}{1 \text{ mol}} = 3.353 \times 10^{24} \text{ molecules of FeO} \]