AMSAT CHEM 1H TOPIC#4
ATOM - MOLE NOTES

RELATING MASS TO NUMBER OF ATOMS

- The Mole (mol)
  - SI unit for amount
    - A dozen is an amount
      - 12 of anything
    - A gross is an amount
      - A dozen dozen of anything (144)
  - The amount of a substance (particle) that contains as many particles as there are atoms in 12 g of carbon-12.
    - We do not usually order 12 or 24 ears of corn, we order a dozen or two dozen
    - Chemists wants 1 mol or 2mol of a substance

The Mole Visual

- Avogadro's Number
  - Italian scientist, Amedeo Avogadro
  - 6.022×10^{23} particles of anything in one l mole
    - 6.022×10^{23} parts = 1 mole
      - Relationship between parts and mole
      - If every person on Earth (5 billion people) worked to count the atoms in 1 mole of an element, and if each person counted continuously at a rate of 1 atom per second, it would take about 4 million yrs for all the atoms to be counted.

Avogadro's Number Visual

- Formula mass (*FM*)
  - The sum of all the relative atomic masses in a compound
    - Measured in amu
      - H_2O
        - 2H + O = FM
        - 2(1.01) + 16.00 = 18.02 amu
- Molar Mass (*MM*)
  - The mass of 1 mole of a pure substance
    - Element, or compound
      - Gram formula mass (*GFM)* (same as molar mass)
        - The mass in grams of 1 mole of a substance based on the formula
      - Element
        - Equal to the amu of the atom with a label of grams/mol (g/mol)
          - Li → 6.94 amu = 6.94 g/mol
          - Hg →200.59amu = 200.59 g/mol
      - Compound

- Equal to the sum of all of the atoms comprising the compound with a label of g/mol
  - Multiply mass of atom by subscript
  - Subscript outside of parenthesis, multiply through to each atom within
    - H_2O
      - 2H + O = *MM* (or *GFM*)
      - 2(1.01) + 16.00 = 18.02 g/mol
    - $Mg_3(PO_4)_2$
      - 3Mg + 2P + 8O = *MM*
      - 3(24.31) + 2(30.97) + 8(16.00) = 262.87 g/mol

Molar Mass Visual

- **Sample Problem 3.5** – Molar Mass

  Determine the molar mass of each of the following.

  (1) $CaCl_2$ _____

  (2) Au _____

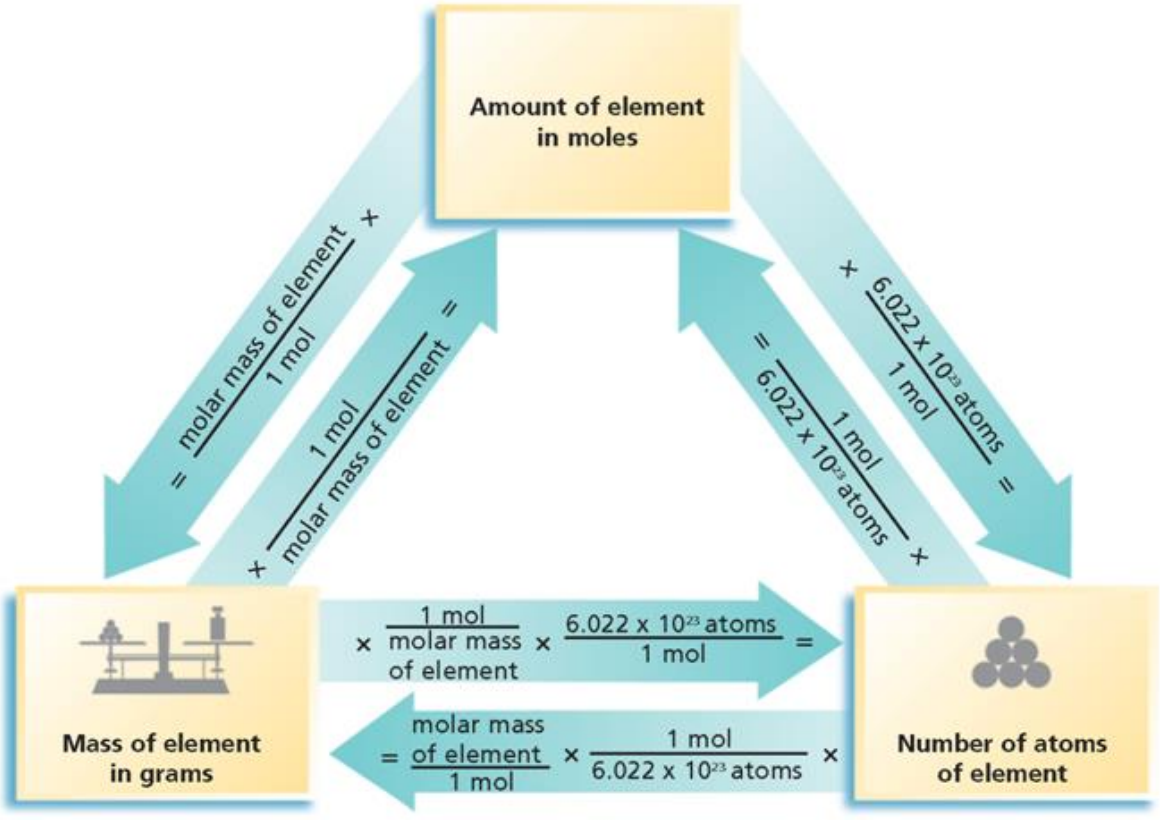
  (3) H_2SO_4 _____

  (4) $CuSO_4 \bullet 5H_2O$ _____

  (5) $C_{11}H_{22}O_{10}$ _____

  (6) $(NH_4)_3P$ _____

Solving Mole Problems



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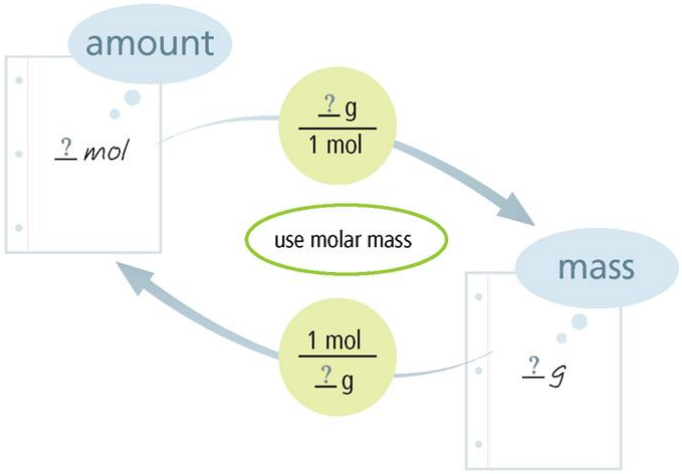
Determining the Mass from the Amount in Moles



- Grams/Moles Conversions
  - Use (#grams = 1 mole) relationship
  - Given: grams Unk: moles
    - Divide by *MM* (or set up conversion factor of 1mol/grams)

$$\frac{4.00\text{g He}}{} \left| \frac{1\text{mol He}}{4.00\text{g He}} \right. = 1.00\text{ mol He}$$

  - Given: moles Unk: grams
    - Multiply by *MM* (or set up conversion factor of grams/1mol)
      - $\frac{2.00\text{mol He}}{} \left| \frac{4.00\text{g He}}{1\text{ mol He}} \right. = 8.00\text{g He}$
  - **Sample Problem 3.6** – Mole/Grams Conversions

    What is the mass in grams of 3.50 mol of the element, Cu? Ans: 222g Cu

    Practice

    (1) What is the mass in grams of 0.375 mol of the element K? Ans: 14.7 g K

    (2) What is the mass in grams of 2.51 mol of the compound glucose, $C_6H_{12}O_6$? Ans: 452g $C_6H_{12}O_6$
  - **Sample Problem 3.7** – Grams/Mole Conversions

    A chemist produced 11.9g of Al. How many moles of Al were produced? Ans: 0.441 mol Al

    Practice

    (1) How many moles of Ca, are in 5.00g of Ca? Ans: 0.125 mol Ca

    (2) How many moles of calcium nitrate, $Ca(NO_3)_2$, are in 50.0g? Ans: 0.305 mol $Ca(NO_3)_2$
- Moles/Parts Conversions
  - Use (1 mol = 6.022×10^{23}parts) relationship
  - Parts
    - Ions, molecules, formula units (f.u.), or atoms

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- Given: moles Unk: parts
  - Multiply by Avogadro's number and divide by 1 mol
    - $\frac{2.00 \text{ mole He}}{} \left| \frac{6.022 \times 10^{23} \text{ atoms He}}{1 \text{ mol He}} \right. = 1.20 \times 10^{24} \text{ atoms He}$
- Given: parts Unk: moles
  - Multiply by 1 mol and divide by Avogadro's number
    - $\frac{1.80 \times 10^{24} \text{ atoms He}}{} \left| \frac{1 \text{ mol He}}{6.022 \times 10^{23} \text{ atoms He}} \right. = 3.00 \text{ mol He}$
- **Sample Problem 3.8** – Parts/Moles Conversions
  How many moles of Ag are in 3.01×10^{23} atoms of Ag? Ans: 0.500 mol Ag
  Practice
  How many moles of NaCl are in 4.23×10^{23} formula units of NaCl? Ans: 0.702 mol NaCl
- **Sample Problem 3.9** – Moles/Parts Conversions
  How many atoms of Al, are in 2.75 mol of Al? Ans: 1.66×10^{24} atomsAl
  Practice
  How many molecules of CH_2O are in 0.928mol of CH_2O? Ans: 5.59×10^{23}molecules

- Grams/Parts Conversions
  - Use (MM = 6.022×10^{23}parts) relationship
  - Given: mass Unk: parts
    - Multiply by Avogadro's number and divide by *MM*
      - $\frac{4.00 \text{g He}}{} \left| \frac{6.022 \times 10^{23} \text{atoms}}{4.00 \text{g}} \right. = 6.022 \times 10^{23} \text{atoms He}$
  - Given: parts Unk: mass
    - Multiply by *MM* and divide by Avogadro's number
      - $\frac{1.20 \times 10^{24} \text{atoms He}}{} \left| \frac{4.00 \text{g}}{6.022 \times 10^{23} \text{ atoms}} \right. = 8.00 \text{g He}$
  - **Sample Problem 3.10** – Parts/Grams Conversions
    What is the mass in grams of 1.20×10^{8} atoms of Cu? Ans: 1.27×10^{-14}gCu
    Practice
    What is the mass in grams of 9.65×10^{25} molecules of H_2O? Ans: 2.89×10^{3} grams
  - **Sample Problem 3.11** – Grams/Parts Conversions
    How many atoms of S are in 4.00g of S? Ans: 7.51×10^{22}atoms
    Practice
    How many formula units are in 35.5g of $MgCl_2$? Ans: 2.25×10^{23} f.u.'s

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