Empirical and Molecular Formula Notes

- The **empirical formula** of a compound shows the ratio of elements present in a compound.
- The **molecular formula** of a compound shows how many atoms of each element are present in a molecule of a compound.
  - Example: the compound butene has a molecular formula of \( C_4H_8 \). The empirical formula of butene is \( CH_2 \) because there is a 1:2 ratio of carbon atoms to hydrogen atoms.

**Finding the molecular formula when given the empirical formula**

- The molecular formula is just a multiple of the empirical formula.
- Take a look at butene:
  - \( CH_2 \times n = C_4H_8 \) so \( n=4 \). What is the molar mass of butene?
    - If the empirical formula of a compound is \( CH_2 \), then you can find the molar mass of the empirical formula: \( 12.0 + 2(1.0) = 14.0 \) g/mol
    - \( 14.0 \) g/mol \( \times 4 = 56 \) g/mol
- What if I have a compound with an empirical formula of \( CH_2 \) that has a molar mass of \( 84 \) g/mol. What is the molecular formula of this compound?
  - \( 14.0 \) g/mol \( \times n = 84 \) g/mol so \( n = 6 \)
  - \( CH_2 \times 6 = C_6H_{12} \)

- **Try a few:**
  1. What is the empirical formula of \( C_8H_{10} \)? \( C_6H_{12}O_6 \)?
  2. What is the molecular formula of a molecule that has an empirical formula of \( NO_2 \) and a molar mass of \( 92 \) g/mol?
  3. Consider a molecule that has an empirical formula of \( SO_3 \) and a molecular formula of \( S_3O_9 \). What is the molar mass of the molecule?
Calculating empirical formula from percent composition

Answer this question:
What is the empirical formula of a compound that contains 25.53% Mg and 74.47% Cl?

Steps:
1. Assume a 100 g sample of the compound
2. Convert all percentages into grams. Example: 50% = 50g/100g, 21% = 21 g
3. Find the atomic mass of each element using the periodic table
4. Calculate the moles of each element present
5. Divide the moles of each element by the smallest number of moles to get a mole ratio
6. If the numbers in this ratio are whole numbers, convert into an empirical formula
7. If the numbers in this ratio are NOT whole numbers, multiply them by a number that will make them both whole.

Try your own:
A compound with a molecular mass of 34.0 g/mol is known to contain 5.88% H and 94.12% oxygen. What is the molecular formula for this compound? (Hint: you must find the empirical formula first!!)