Read Section 5.3 before viewing the slide show.
Unit 18
Avogadro’s Number and the Mole

• Significance of Avogadro’s Number (5.3)
• Size of Avogadro’s Number (5.3)
• Definition of a Mole (5.3)
• Formula Mass (and Molecular Mass) (5.3)
Introduction to Avogadro’s Number

• Consider everyday items that we acquire in multiples:
  • 12 eggs is one dozen
  • 144 of anything is called a gross
  • 500 sheets of paper is a ream

• These counting units have been accepted because they provide a convenient measure for the items being considered. In chemistry, the accepted counting unit is called the mole.

  • The mole has a LOT of atoms and/or molecules in it. The number is roughly $602213670000000000000000$ atoms or molecules in a mole. This number could be used to count other things, but it would not be particularly helpful in counting eggs, for example. The number is called Avogadro’s number and is usually written as $6.02 \times 10^{23}$.
Significance of Avogadro’s Number

• Consider the following analogy:
  • 1 dozen is 12 of whatever we want to count
  • 1 mole is 6.02 x 10^{23} of whatever we want to count

<table>
<thead>
<tr>
<th># of things</th>
<th># dozen</th>
<th># moles</th>
</tr>
</thead>
<tbody>
<tr>
<td>48 eggs</td>
<td>\frac{48 \text{ eggs}}{12} = 4 \text{ dozen eggs}</td>
<td>\frac{48 \text{ eggs}}{6.02 \times 10^{23}} = 7.97 \times 10^{-23} \text{ moles eggs}</td>
</tr>
<tr>
<td>6.45 \times 10^9 \text{ people}</td>
<td>\frac{6.45 \times 10^9 \text{ people}}{12} = 5.38 \times 10^8 \text{ dozen people}</td>
<td>\frac{6.45 \times 10^9 \text{ people}}{6.02 \times 10^{23}} = 1.07 \times 10^{-14} \text{ mole people}</td>
</tr>
<tr>
<td>7.45 \times 10^{24} \text{ atoms N}</td>
<td>\frac{7.45 \times 10^{24} \text{ atoms N}}{12} = 6.21 \times 10^{23} \text{ dozen atoms N}</td>
<td>\frac{7.45 \times 10^{24} \text{ atoms N}}{6.02 \times 10^{23}} = 12.4 \text{ mole atoms N}</td>
</tr>
</tbody>
</table>

• Notice the mole is a much more convenient unit for counting large numbers of things while the dozen works well for smaller numbers

• Calculator note: Try the calculations above on your calculator. Enter the scientific notation numbers by putting in, for example, 6.45 EXP (or maybe EE) and then the exponent on your calculator. When you read the answers in the calculator window, the power of ten is given by the digits on the far right.
The “Value” of Avogadro’s Number

• Counting donuts to determine dozens, paper to determine reams, etc. is not too horrific a task. However, counting atoms is a virtual impossibility in any practical sense. Thus, there has to be a different way to get to atom counts.

• Back to dozens for a minute. Suppose you had to count how many sugar donuts were in a semi-truck filled with just sugar donuts. You could spend considerable time counting them one-by-one. Or, you could measure the mass of a dozen of them, then measure the mass of donuts in the truck, and divide the mass in the truck by the mass of a dozen. This would be how many dozen donuts were in the truck.

• Shift to atoms or molecules. Suppose you had to find out how many moles of water molecules were in a glass of water. You can get the mass of water in the glass, but finding the relationship between mass and number of moles is a little more difficult. To get one mole of water molecules, you would have to count out Avogadro’s number of water molecules – an impossibility – to get their mass. Thus, the “value” of Avogadro’s number. We can find the mass in one mole of water easily by using the periodic table.
The Mole and the Periodic Chart

Consider the abbreviated periodic table below.

- The atomic number is the integer value in each box and indicates the number of protons in the nucleus of an atom of the element.
- The other number in each box is the atomic mass of the element.

Avogadro’s number is special because, if you pile up $6.02 \times 10^{23}$ atoms, the mass of those atoms will be equal to the atomic mass in grams. The other name for this number of atoms – one mole.

Thus one mole of a substance is the amount of substance that contains its atomic mass in grams.
Formula Mass or Molecular Mass

• If the substance being considered is a compound or multi-atom molecule, the mass of one mole is obtained by adding up the atomic mass of all of the atoms in the species.

• Examples:
  
  - \(\text{H}_2\text{O}\)  
    - Molecular mass = \(2 \times 1 + 1 \times 16 = 18\)
  
  - \(\text{NH}_4\text{Cl}\)  
    - Formula mass = \(1 \times 14 + 4 \times 1 + 35.5 = 53.5\)
  
  - \(\text{Ca(NO}_3)_2\)  
    - Formula mass = \(1 \times 40 + 2 \times 14 + 6 \times 16 = 164\)

• There is not a functional difference between the terms formula mass and molecular mass. Formula mass is usually used to refer to species that are not molecular (ionic, for example) and molecular mass is used to refer to those that are molecular. Adding up the atomic masses does not change.