Relative Mass and the Mole

How can atoms be counted using a balance?

Why?

Consider the following equation for a chemical reaction: \(2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}\)

This can be interpreted as two molecules of hydrogen and one molecule of oxygen combining to form two water molecules. But how often do chemists limit their reactions to one or two molecules? Usually a reaction is done with an unimaginable number of molecules. How then do chemists know they have the right mix? The molecules need to be quickly counted! How do we count molecules? The answer is the unit called the mole. This activity will start by considering two egg farmers (a chicken farmer and a quail farmer). They produce such large numbers of eggs that they can't count them all individually, so they count in dozens of eggs in some cases, while in other cases they use mass. Weighing is often easier than counting!

Model 1 – Eggs

<table>
<thead>
<tr>
<th>Chicken</th>
<th>Quail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of eggs in the sample</td>
<td>Number of eggs in the sample</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>438</td>
<td>438</td>
</tr>
<tr>
<td>1 dozen</td>
<td>1 dozen</td>
</tr>
<tr>
<td>1 million</td>
<td>1 million</td>
</tr>
</tbody>
</table>

1. Consider the data in Model 1.
   a. What is the mass of a standard chicken egg?
      \[37.44 \text{ g}\]
   b. What is the mass of a standard quail egg?
      \[2.34 \text{ g}\]
   c. Show mathematically how the 16:1 ratio of masses was calculated in the last column of Model 1.
      \[
      \frac{37.44 \text{ g}}{2.34 \text{ g}} = \frac{x}{1} \rightarrow x = 16
      \]

2. Use a calculator to complete the table in Model 1. Divide the work among group members. Reduce all ratios to the lowest whole numbers possible.
3. Imagine you have two baskets—one filled with quail eggs and one filled with the same number of chicken eggs.

   a. Which basket would be heavier?

      Chicken eggs.

   b. How many times heavier would that basket be?

      The basket of chicken eggs would be 16x heavier than the basket of quail eggs.

   c. Explain mathematically how it is possible for you to answer part b with confidence, even though you don’t know the actual number of eggs.

      Each individual chicken egg is heavier, so if there are the same number of eggs in each basket, the total mass of the chicken egg basket will be greater.

4. A farmer weighs out 32.0 kg of chicken eggs.

   a. What mass of quail eggs would he need to weigh out to have the same number of eggs in both samples?

      \[
      \frac{1}{16} = \frac{x}{32.0 \text{ kg}} \rightarrow x = 2.0 \text{ kg}
      \]

   b. If the farmer had weighed out 32.0 pounds of chicken eggs (rather than kilograms), what mass of quail eggs would he need to weigh out to have the same number of eggs in both samples?

      2.0 lbs

5. A farmer makes up a new counting unit called a “clucky.”

   a. If the farmer had 3 clucksters of chicken eggs and 3 clucksters of quail eggs, what could you say about the ratio of their masses?

      The 3 clucksters of chicken eggs will be 16 times heavier than the 3 clucksters of quail eggs.

   b. Does it matter in this problem how many eggs are in a “clucky”? Explain.

      It doesn’t matter how many eggs are in a “clucky.” The 16:1 ratio will always be true as long as the number of eggs is the same.

**Stop**

**Read This!**

Let’s take what we learned in the egg model and apply it to atoms. Like eggs, atoms of the same element may have slightly different masses (remember isotopes). The periodic table lists an average atomic mass for the atoms in a sample of each element. These masses are recorded in “atomic mass units” where 1 amu is approximately equal to the mass of a proton (or neutron).
### Model 2 – Atoms

<table>
<thead>
<tr>
<th>Oxygen</th>
<th>Sulfur</th>
<th>Ratio of numbers of atoms</th>
<th>Ratio of masses of atoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of atoms in the sample</td>
<td>Mass of the sample</td>
<td>Number of atoms in the sample</td>
<td>Mass of the sample</td>
</tr>
<tr>
<td>1</td>
<td>16.00 amu</td>
<td>1</td>
<td>32.00 amu</td>
</tr>
<tr>
<td>10</td>
<td>160.0 amu</td>
<td>10</td>
<td>320.0 amu</td>
</tr>
<tr>
<td>1 dozen</td>
<td>192 amu</td>
<td>1 dozen</td>
<td>384 amu</td>
</tr>
<tr>
<td>1 million</td>
<td>16,000,000 amu</td>
<td>1 million</td>
<td>32,000,000 amu</td>
</tr>
<tr>
<td>1 mole</td>
<td>16.00 grams</td>
<td>1 mole</td>
<td>32.00 grams</td>
</tr>
</tbody>
</table>

*Note:* The masses shown for oxygen and sulfur have been rounded to make the arithmetic a bit easier.

6. What is the ratio of the mass of an oxygen atom to the mass of a sulfur atom?  

1:2

7. Fill in the table in Model 2 in a similar fashion to the eggs table in Model 1. Divide the work evenly among group members. Reduce all ratios to the lowest whole numbers possible.

8. Circle the phrase below that completes the sentence.

When two samples contain the same number of atoms ____________, the ratio of the sample masses will be equal to the ratio of the atoms' masses.  

9. Explain why it is not necessary to know how many atoms are in “1 mole” to finish the last row of the table in Model 2.

*The mass ratio does not depend on the number of atoms in a sample, as long as the number is the same for both elements.*

10. How would the number of oxygen atoms in a 16.00 lbs sample compare to the number of sulfur atoms in a 32.00 lbs sample?

*The ratio of masses for a mole of oxygen and a mole of sulfur is 1:2, so the ratio of number of atoms in 16- and 32-lb samples will still be 1:1.*

11. In the front of the room, there is a bottle that contains a 32.00 g sample of sulfur. This is 1 mole of sulfur. Estimate how many atoms are in the bottle. Your group must reach consensus.

*Answers will vary. It should be something really large!*

### Read This!

A long time ago chemists discovered what you have just discovered: *The relative masses of the elements can be used to "count" atoms.* If you measure out a sample equal to an atom's atomic mass in grams, you always end up with the same number of atoms. Chemists call that quantity the **mole**—a quantity of any sample whose mass is equal to its atomic mass in grams.
Model 3 – Molar Mass

<table>
<thead>
<tr>
<th>Average Mass of a Single Particle</th>
<th>Average Mass of One Mole of Particles (Molar Mass)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 atom of hydrogen (H)</td>
<td>1.01 amu</td>
</tr>
<tr>
<td>1 atom of copper (Cu)</td>
<td>63.55 amu</td>
</tr>
<tr>
<td>1 molecule of oxygen (O₂)</td>
<td>32.01 amu</td>
</tr>
<tr>
<td>1 molecule of water (H₂O)</td>
<td>18.02 amu</td>
</tr>
<tr>
<td>1 formula unit of sodium chloride (NaCl)</td>
<td>58.44 amu</td>
</tr>
<tr>
<td></td>
<td>1 mole of hydrogen atoms (H) 1.01 g</td>
</tr>
<tr>
<td></td>
<td>1 mole of copper atoms (Cu) 63.55 g</td>
</tr>
<tr>
<td></td>
<td>1 mole of oxygen molecules (O₂) 32.01 g</td>
</tr>
<tr>
<td></td>
<td>1 mole of water molecules (H₂O) 18.02 g</td>
</tr>
<tr>
<td></td>
<td>1 mole of sodium chloride formula units (NaCl) 58.44 g</td>
</tr>
</tbody>
</table>

12. Look at a periodic table. What number in each element box would a chemist use to find the values in the “Average Mass of a Single Particle” column in Model 3?

*The average atomic mass values, which are given with amu for a unit.*

13. How is the mass of a single particle changed to get the mass of one mole of particles?

*Same number from the periodic table, but with grams for a unit.*


*A gram is a much larger unit than the atomic mass unit, so the 18.016 g sample has more atoms. 18.016 amu is the mass of one water molecule!*

15. If the formula mass of iron(II) sulfate (FeSO₄) is 151.9 amu, what is the molar mass of iron(II) sulfate?

(a) 151.9 g

(b) \((1 \text{ mol of } \text{ hydrogen} \times 10.02 \text{ g}) + (1 \text{ mol of oxygen} \times 16.00 \text{ g}) = 18.02 \text{ g}\)

16. Use a periodic table to calculate the molar mass of ammonia (NH₃).

17.0 g

17. How would the number of atoms in a 1.01 g sample of hydrogen compare to the number of atoms in a 63.55 g sample of copper?

*The number of atoms in each sample would be the same.*

Read This!

So how many “things” are in a mole? By estimating the size of atoms and taking volume measurements of one mole samples scientists can estimate that

\[ 1 \text{ mole} = 6.022 \times 10^{23} \text{ particles} \text{ or } 602 \text{ 200 000 000 000 000 000 000 particles} \]

(More than you could count in a lifetime!)

This number is called Avogadro’s number, named after Amedeo Avogadro.

#18

1 atom of helium has a mass of 4.00 amu.

1 mole of helium contains \(6.022 \times 10^{23}\) atoms, and has a mass of 4.00 g.

1 formula unit of calcium chloride (CaCl₂) has a mass of 110.99 amu.

1 mole of CaCl₂ contains \(6.022 \times 10^{23}\) formula units, and has a mass of 110.99 g.

POGIL™ Activities for High School Chemistry
What is a mole?
A mole, commonly abbreviated \( \text{mol} \), is the SI unit used to measure the amount of a substance. The amount in a mole is \( 6.02 \times 10^{23} \) particles. This amount is also known as Avogadro's number.

1 mol = \( 6.02 \times 10^{23} \) particles

The number of atoms is for an element.
The number of formula units is for an ionic compound.
The number of molecules is for a compound that is covalently bonded.

Dimensional Analysis
Given \( (\text{NaCl}) \) find
1. Given 4.25 mol of sodium chloride, determine the number of formula units.

\[
\begin{array}{c|c}
\text{NaCl} & \text{f.u. NaCl} \\
4.25 \text{ mol} & 1 \text{ mol NaCl} \\
\hline
\end{array}
\]

2. Calculate the number of molecules in 12.6 mol of sulfur dioxide.

\[
\begin{array}{c|c}
\text{SO}_2 & \text{mol. NaCl} \\
12.6 \text{ mol} & \text{f.u. NaCl} \\
\hline
\end{array}
\]

3. How many moles are in \( 6.75 \times 10^{24} \) atoms of nickel?

\[
\begin{array}{c|c}
\text{Ni} & \text{f.u. Ni} \\
6.75 \times 10^{24} \text{ atoms Ni} & 1 \text{ mol Ni} \\
\hline
\end{array}
\]

4. How many moles are in \( 6.78 \times 10^{23} \) formula units of magnesium chloride?

\[
\begin{array}{c|c}
\text{f.u. MgCl}_2 & \text{f.u. MgCl}_2 \\
6.78 \times 10^{23} \text{ f.u. MgCl}_2 & 1 \text{ mol MgCl}_2 \\
\hline
\end{array}
\]
Molar Mass

Definition of Molar Mass:

The mass of 1 mole of an element or compound.

Atomic mass has the units \( \text{amu} \) and is the color \( \text{red} \) on the periodic table.

The RED numbers are also the molar mass. It's units are g.

Element Molar Mass

5. Molar mass of carbon (C) = 12.011 g \( \rightarrow \) 12.01 g

6. What would the molar mass of boron (B) be? \( 10.81 \) g

Compound Molar Mass: add up all of the element molar masses

What is the molar mass of:

7. a) \( \text{C}_8\text{H}_11\text{NO}_2 \)
   \[
   \begin{align*}
   \text{C} &= 12.011 \text{ g (4)} \\
   \text{H} &= 1.011 \text{ g (11)} \\
   \text{N} &= 14.01 \text{ g (1)} \\
   \text{O} &= 16.00 \text{ g (2)}
   \end{align*}
   \]
   \[= 153.20 \text{ g} \]

8. Calculate the mass in grams of 0.0450 moles of chromium (Cr).
   \[
   \begin{align*}
   0.0450 \text{ mol Cr} \times 52.00 \text{ g Cr} &= 2.34 \text{ g Cr} \\
   \hline
   1 \text{ mol Cr}
   \end{align*}
   \]

9. What is the mass of 4.35 moles of sulfuric acid, \( \text{H}_2\text{SO}_4 \)?
   \[
   \begin{align*}
   4.35 \text{ mol H}_2\text{SO}_4 &\times 98.09 \text{ g H}_2\text{SO}_4 \\
   \hline
   1 \text{ mol H}_2\text{SO}_4 \\
   \end{align*}
   \]
   \[= 426.69 \text{ g H}_2\text{SO}_4 \times 427 \text{ g H}_2\text{SO}_4 \]

10. Calculate the number of moles of 321 g of lead (II) chloride.
    \[
    \begin{align*}
    \text{Pb} &= 207.20 \text{ g} \\
    \text{Cl} &= 35.45 \text{ g (2)} \\
    \hline
    \text{278.10 g PbCl}_2
    \end{align*}
    \]
    \[
    \begin{align*}
    321 \text{ g PbCl}_2 &\times 1 \text{ mol PbCl}_2 \\
    \hline
    278.10 \text{ g PbCl}_2 \\
    \end{align*}
    \]
    \[= 1.15 \text{ mol PbCl}_2 \]
11. How many formula units are in 124 g of mercury(II) chloride?

\[
\begin{align*}
\text{Hg} &= 200.59 g \\
\text{Cl} &= 35.46 g (2) \\
\hline
271.49 g \text{ HgCl}_2 & \text{ find} \quad \text{given} \\
1.24 g \text{ HgCl}_2 &= 1 \text{ mol HgCl}_2 \\
2.7149 g \text{ HgCl}_2 &= 1 \text{ mol HgCl}_2 \\
&= 2.75 \times 10^{23} \text{ f.u. HgCl}_2
\end{align*}
\]

12. What is the mass in grams in \(1.50 \times 10^{15}\) molecules of sulfur dioxide?

\[
\begin{align*}
\text{S} &= 32.07 g \\
\text{O} &= 16.00 g (2) \\
\hline
64.07 g \text{ SO}_2 &= 1 \text{ mol} \\
&= 1.60 \times 10^{-7} g \text{ SO}_2
\end{align*}
\]

13. A sample of aluminum chloride has a mass of 35.6 g.

a. How many moles of chloride ions are present?

\[
\begin{align*}
\text{Al} &= 26.98 g \\
\text{Cl} &= 35.46 g (3) \\
\hline
133.33 g \text{ AlCl}_3 & \text{ find} \quad \text{given} \\
35.6 g \text{ AlCl}_3 &= 1 \text{ mol AlCl}_3 \\
133.33 g \text{ AlCl}_3 &= 1 \text{ mol AlCl}_3 \\
&= 0.801 \text{ mol Cl}^{-}
\end{align*}
\]

b. How many chloride ions are present?

2 ways

1. Longer: start w/ 35.6 g ...

or

2. \(0.801 \text{ mol Cl}^{-} \times 6.02 \times 10^{23} \text{ Cl}^{-} = 4.82 \times 10^{23} \text{ Cl}^{-}\) or \(\text{Cl}^{-}\)

14. How many oxygen atoms are in 37.5 grams of \(\text{SO}_3\)?

\[
\begin{align*}
\text{S} &= 32.07 \\
\text{O} &= 16.00 (3) \\
\hline
80.07 g \text{ SO}_3 & \text{ find} \\
37.5 g \text{ SO}_3 &= 1 \text{ mol SO}_3 \\
&= 4.82 \times 10^{23} \text{ ions SO}_3
\end{align*}
\]
DO THESE ON A SEPARATE SHEET OF PAPER THAN YOUR BOOK WORK!!!

Mole

1. What is a mole in chemistry? The SI unit to measure the amount of a substance.
2. How is a mole similar to a dozen? It is a specific amount of representative particles.
4. What is another name for $6.02 \times 10^{23}$? Avogadro's number.
5. What is the particle called for:
   a. an element = atoms
   b. an ionic compound = formula units or ions
   c. a covalent compound = molecules
6. Explain why chemists use the mole. The numbers would be extremely large if they didn’t.
7. Arrange the following from the smallest number of representative particles to the largest: 1.25 x $10^{25}$ atoms Zn; 3.56 mol Fe; 6.78 x $10^{22}$ molecules glucose (C$_6$H$_{12}$O$_6$); 6.78 x $10^{22}$ molecules glucose (C$_6$H$_{12}$O$_6$); 3.56 mol Fe = 2.14 x $10^{24}$ atoms Fe, 1.25 x $10^{25}$ atoms Zn. glucose $<$ Fe $<$ Zn
8. Determine the number of atoms in 3.50 mol of Zn. 2.11x$10^{24}$ atoms Zn.
9. Calculate the number of molecules in 12.5 mol of H$_2$O. 7.53x$10^{24}$ molecules H$_2$O.
10. Given 4.25 mol AgNO$_3$ determine the number of formula units. 2.56x$10^{24}$ Formula units Ag NO$_3$.

How many moles are contained in each of the following?

11. 6.75 x $10^{24}$ atoms Al. 11.2 moles Al.
12. 1.75x$10^{24}$ molecules of CO$_2$. 2.91 moles CO$_2$.
13. 2.58 x $10^{23}$ formula units of ZnCl$_2$. 0.429 moles ZnCl$_2$.

Molar Mass Dimensional Analysis

14. What is the definition of molar mass? The mass in grams of one mole of any pure substance.
15. The mass of a single atom is usually given in the unit amu. Would it be possible to express the mass of a single atom in grams? Explain. Because 1 mole = 6.02 x 10 23 atoms and the molar mass of an element is equal to one mole, the mass of a single atom can be calculated by dividing the mass of one mole by Avogadro's number.
16. Arrange the following in order of mass from the smallest mass to the largest: 1.0 mol Ar, 3.0 x $10^{24}$ atoms Ne, 20 g Kr, 1.0 mol Ar, 3.0 x $10^{24}$ atoms Ne.

17. (NH$_4$)$_3$PO$_4$ 149.12 g

Determine the mass in grams of each of the following

18. 5.57 mol Al 1.50 x $10^2$ g Al ← * s.f.
19. What is the mass of 4.55x$10^{-2}$ moles if ZnCl$_2$? 6.20 g.
20. How many grams are in 2.3 mol of calcium phosphate? Ca$_3$(PO$_4$)$_2$ = 310.18 g/mol, 710 g ← * s.f.

Calculate the number of moles in each of the following

21. 125 g Zn(OH)$_2$. 1.26 mol Zn(OH)$_2$.
22. 1.00 kg HCl 27.4 mol HCl.

How many atoms are in each of the following samples.

23. 12.5 g Au(NO$_3$)$_3$. 1.96 x $10^{22}$ f.u. Au(NO$_3$)$_3$.

What is the mass of each of the following samples.

24. 7.02 x $10^{24}$ atoms Bi 2440 g Bi.
25. 2.00 x $10^{24}$ molecules NO$_2$. 153 g NO$_2$.
26. 6.40 x $10^{22}$ formula units NaCl. 6.21 g NaCl.
27. Determine the number of moles of sulfate ions present in 2.00 mol of Fe$_2$(SO$_4$)$_3$. 6.00 moles SO$_4^{2-}$ ions.
28. How many oxygen atoms are present in 4.00 mol of phosphorus pentoxide. 1.20 x $10^{25}$ atoms of O.
1. What is a mole in chemistry? **The SI unit to measure the amount of a substance**
2. How is a mole similar to a dozen? **It is a specific amount of representative particles**
3. How many particles in a mole? **6.02 x 10^23 representative particles**
4. What is another name for 6.02 x 10^23? **Avogadro’s number**
5. What is the particle called for:
   a. an element = **atoms**
   b. an ionic compound = **formula units & ions**
   c. a covalent compound = **molecules**
6. Explain why chemists use the mole. **The numbers would be extremely large if they didn’t**

7. Smallest: 6.78 x 10^22 molecules glucose
   Second:
   | 3.56 mol Fe | 6.02 x 10^23 atoms Fe | = 2.14 x 10^24 atoms Fe |
   | 1 mol Fe    |                      |                        |
   Largest: 1.25 x 10^25 atoms Zn

8.

9.

10.

11.

12.

13.

14. What is the definition of molar mass? **The mass in grams of one mole of any pure substance**
15. The mass of a single atom is usually given in the unit amu. Would it be possible to express the mass of a single atom in grams? Explain. **Because 1 mole = 6.02 x 10^23 atoms and the molar mass of an**
element is equal to one mole, the mass of a single atom can be calculated by dividing the mass of one mole by Avogadro’s number.

16. Smallest mass: 20 g Kr
   Second mass:
   \[
   \begin{array}{ccc}
   1.0 \text{ mol Ar} & 39.95 \text{ g Ar} & = 40. \text{ g Ar} \\
   \text{1 mol Ar} & & \\
   \text{Largest mass:}
   \end{array}
   \]
   \[
   \begin{array}{cccc}
   3.0 \times 10^{24} \text{ atoms Ne} & \text{1 mol Ne} & 20.18 \text{ g Ne} & = 1.0 \times 10^2 \text{ g Ne} \\
   6.02 \times 10^{23} \text{ atoms Ne} & \text{1 mol Ne} & & \\
   \end{array}
   \]
   \[
   \begin{array}{cccc}
   3(14.01 \text{ g/mol}) = & 42.03 \text{ g/mol} \\
   \text{H: } 12(1.01 \text{ g/mol}) = & 12.12 \text{ g/mol} \\
   \text{P: } & 30.97 \text{ g/mol} \\
   \text{O: } 4(16.00 \text{ g/mol}) = & 64.00 \text{ g/mol} \\
   & & 149.12 \text{ g/mol} \\
   \end{array}
   \]

17. N: 
   \[
   \begin{array}{cccc}
   5.57 \text{ mol Al} & 26.98 \text{ g Al} & = 1.50 \times 10^2 \text{ g Al} \\
   \text{1 mol Al} & & \\
   \end{array}
   \]

19. 
   \[
   \begin{array}{cccc}
   4.55 \times 10^{-2} \text{ mol ZnCl}_2 & 136.29 \text{ g ZnCl}_2 & = 6.20 \text{ g ZnCl}_2 \\
   \text{1 mol ZnCl}_2 & & \\
   \end{array}
   \]

20. 
   \[
   \begin{array}{cccc}
   2.3 \text{ mol Ca}_3(\text{PO}_4)_2 & 310.18 \text{ g Ca}_3(\text{PO}_4)_2 & = 710 \text{ g Ca}_3(\text{PO}_4)_2 \\
   \text{1 mol Ca}_3(\text{PO}_4)_2 & & \\
   \end{array}
   \]

21. 
   \[
   \begin{array}{cccc}
   125 \text{ g Zn(OH)}_2 & \text{1 mol Zn(OH)}_2 & = 1.26 \text{ mol Zn(OH)}_2 \\
   99.41 \text{ g Zn(OH)}_2 & & \\
   \end{array}
   \]

22. 
   \[
   \begin{array}{cccc}
   1.00 \text{ kg HCl} & 1000 \text{ g HCl} & \text{1 mol HCl} & = 27.4 \text{ mol Fe} \\
   \text{1 kg HCl} & & 36.46 \text{ g HCl} & \\
   \end{array}
   \]

23. 
   \[
   \begin{array}{cccc}
   12.5 \text{ g Au(NO}_3)_2 & \text{1 mol Au(NO}_3)_2 & 6.02 \times 10^{23} \text{ atoms Au(NO}_3)_2 & = 2.35 \times 10^{22} \text{ formula units Au(NO}_3)_2 \\
   320.69 \text{ g Au(NO}_3)_2 & \text{1 mol Au(NO}_3)_2 & & \\
   \end{array}
   \]

24. 
   \[
   \begin{array}{cccc}
   7.06 \times 10^{24} \text{ atoms Bi} & \text{1 mol Bi} & 208.98 \text{ g Bi} & = 2440 \text{ g Bi} \\
   6.02 \times 10^{23} \text{ atoms Bi} & \text{1 mol Bi} & & \\
   \end{array}
   \]

25. 
   \[
   \begin{array}{cccc}
   2.00 \times 10^{24} \text{ atoms NO}_2 & \text{1 mol NO}_2 & 46.01 \text{ g NO}_2 & = 153 \text{ g NO}_2 \\
   6.02 \times 10^{23} \text{ atoms NO}_2 & \text{1 mol NO}_2 & & \\
   \end{array}
   \]
### Table 26

<table>
<thead>
<tr>
<th>Formula Units</th>
<th>Concentration</th>
<th>Mass (g)</th>
<th>Combination</th>
</tr>
</thead>
<tbody>
<tr>
<td>$6.40 \times 10^{22}$</td>
<td>1 mol NaCl</td>
<td>4.00 g NaCl</td>
<td>= 58.44 g NaCl</td>
</tr>
<tr>
<td>$6.02 \times 10^{23}$</td>
<td>1 mol NaCl</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 27

<table>
<thead>
<tr>
<th>Concentration</th>
<th>Sulfate Ions</th>
<th>Combination</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.00 mol Fe$_2$(SO$_4$)$_3$</td>
<td>3 mol sulfate ions</td>
<td>= 6.00 mol sulfate ions</td>
</tr>
<tr>
<td>1 mol Fe$_2$(SO$_4$)$_3$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 28

<table>
<thead>
<tr>
<th>Concentration</th>
<th>O</th>
<th>Combination</th>
<th>O Atoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.00 mol P$_2$O$_5$</td>
<td>5 mol</td>
<td>$6.02 \times 10^{23}$</td>
<td>= 1.204 x $10^{25}$</td>
</tr>
<tr>
<td>1 mol P$_2$O$_5$</td>
<td>1 mol O</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Vocabulary: Define each term

1. Avogadro's number:
The number of representative particles in a mole, and can be rounded to three significant digits: $6.02 \times 10^{23}$

2. Mole:
The SI base unit used to measure the amount of a substance, abbreviated mol; one mole is the amount of a pure substance that contains $6.02 \times 10^{23}$ representative particles.

Practice Questions: (18 problems)
Pg. 346-349
#74, 75, 77, 82, 89, 90, 92, 93, 99, 101, 103, 104, 107, 109, 111, 114, 119, 124

74. Molar Mass is the mass in grams of one mole of any element of compound.

75. They both contain the same number of atoms because a mole of anything contains $6.02 \times 10^{23}$ representative particles.

77. The molar mass of Au is 197.0 g/mol; the molar mass of Ag is 107.9 g/mol. Thus, a mole of Au has a greater mass.

82. The formula for vanillin (C₈H₆O₃) shows there are eight carbon atoms per molecule, more than ascorbic acid or glycerin.

89. a. $1.51 \times 10^{23}$ atoms Ag
   b. $5.15 \times 10^{21}$ formula units NaCl
   c. $2.13 \times 10^{25}$ Molecules CO₂
   d. $2.56 \times 10^{23}$ molecules N₂

90. a. $5.40 \times 10^{-4}$ mol Pb
   b. 8.24 mol of glucose
   c. $2.59 \times 10^{-4}$ mol NaOH
   d. 20.8 mol Cu²⁺ ions

92. a. $8.13 \times 10^{23}$ molecules CS₂
   b. $1.53 \times 10^{23}$ molecules As₂O₃
   c. $7.53 \times 10^{23}$ molecules H₂O
   d. $9.030 \times 10^{25}$ molecules HCl

93. a. $2.08 \times 10^{9}$ mol CO₂
   b. $5.96 \times 10^{2}$ mol NaNO₃
   c. $4.80 \times 10^{3}$ mol CaCO₃

99. a. 24.3 g Li
   b. 0.130 mol Co
   c. 0.0671 mol Kr
   d. 4.12 g As

101. a. $1.67 \times 10^{6}$ g U
     b. 145 g H

103. a. $7.74 \times 10^{22}$ atoms Hg
      b. $3.13 \times 10^{20}$ atoms Zn
      c. $2.3 \times 10^{24}$ atoms Ar
      d. $3.07 \times 10^{21}$ atoms Mg

104. 10.0 g carbon has more atoms than 10.0 g calcium
      10.0 g carbon has $5.01 \times 10^{23}$ atoms
      10.0 g calcium has $1.50 \times 10^{23}$ atoms

107. 3 mol Na; 1 mol P; 4 mol O

109. CaC₄H₆O₄ (calcium acetate): 158.18 g/mol

111. a. 63.02 g/mol HNO₃
      b. 80.05 g/mol NH₄NO₃
      c. 81.39 g/mol ZnO
      d. 129.83 g/mol CoCl₂

114. a. 2.272 mol N₂O
     b. 3.120 mol CH₃OH

119. 0.883 mol Al¹³⁺ ion

124. 1080 g C₆H₁₂O₆