Session 3: LECTURE OUTLINE (SECTION E)

I. Mole
   a. Definition
   b. Examples

II. Molar mass
   a. Definition
   b. Conversion moles to atoms to mass of one atom
   c. Isotopic abundance and reported molar mass
   d. Atomic weight
   e. Molecular weight
   f. Formula weight
   g. Conversion moles to mass and mass to moles

(note, this session should provide plenty of examples and possibly an opportunity for the students to practice during the session)

Suggested Problems: pp F43-F44 E.1, E.5, E.7, E.13, E.21, E.27

The Mole

mole – unit used to describe 6.02×10^{23} of anything

How many atoms of silver are in 3.2 moles of silver?
Given: 3.2 moles Ag
Wanted: number of Ag atoms
Conversion: moles of Ag to atoms of Ag
Conversion Factor: 1 mole = 6.02×10^{23}

Solution:

$$\frac{3.2 \text{ moles Ag}}{} \left| \frac{6.02 \times 10^{23} \text{ atoms Ag}}{1 \text{ mole Ag}} \right. = 1.93 \times 10^{24}$$

The mole is also

- the number of C-12 atoms in 12 g of C-12 sample

$$\frac{12 \text{ amu C-12}}{1 \text{ atom C-12}} \qquad \frac{12 \text{ g C –12}}{1 \text{ mole C-12}}$$

amu – "atomic mass unit" - relative scale

all atomic masses reported below the elemental symbol on the periodic table can be interpreted in units of

$$\frac{\text{amu}}{\text{atom}} \quad \text{or} \quad \frac{\text{g}}{\text{mole}}$$

when we report using g/mole we refer to the unit as molar mass

The molar mass value reported on the periodic table is actually the weighted average of all the isotopes of the given element.
(see example of weighted average on page F41, example E.3)

- use molar mass as a unit factor to convert between moles of atoms or molecules and mass of atoms or molecules and vice versa

Calculate mass in grams of 1.458 moles of gold.
Given: 1.458 moles Au
Wanted: g of Au
Conversion path: moles Au to g of Au
Conversion factors: molar mass of Au, found on periodic table, 197 g/mole

Solution:

$$\frac{1.458 \text{ moles Au}}{} \left| \frac{197 \text{ g Au}}{\text{mole Au}} \right. = 287.2 \text{ g Au}$$

Calculate the number of moles of gold in 2.2 lbs gold.
Given: 2.2 lbs Au
Wanted: moles of Au
Conversion path: lb Au to g Au to moles Au
Conversion factors: $\frac{454 \text{ g}}{1 \text{ lb}}$ $\frac{197 \text{ g Au}}{1 \text{ mole Au}}$

Solution:

$$\frac{2.2 \text{ lbs Au}}{} \left| \frac{454 \text{ g Au}}{1 \text{ lb Au}} \right| \frac{1 \text{ mole Au}}{197 \text{ g Au}} = 5.1 \text{ mole Au}$$

Formula Weight or Molecular Weight

-sum of all the atomic weights in a compound

What is the molecular weight of methane?
First must identify correct formula for methane : CH_4
Next simply count the number and type of atom in the compound, look up the atomic weights on periodic table and add them all up.

Solution:
Read the molecular formula as 1 mole C and 4 moles hydrogen in each 1 mole of the compound.

C is 12 g/mole and H is 1 g/mole

So: (1 X 12) + (4 X 1) = 16 g/mole molecular weight of CH_4

What is the formula weight of ammonium sulfate?

Solution:
First identify correct formula: $(NH_4)_2SO_4$
Count number and type of atoms in formula

In one mole of $(NH_4)_2SO_4$ there are:

2 moles N	2 X 14
8 moles H	8 X 1
1 mole S	1 X 32
4 mole O	4 X 16
$(NH_4)_2SO_4$ =	132 g/mole

Based on the chemical formula we can predict the number of moles of any of the elements contained in the compound, this is called the formula stoichiometry of the compound. In other words there is a simple whole number ratio of atom type within the compound based on the chemical formula.

How many moles of H atoms are found in 4.5 moles of $(NH_4)_2SO_4$?

Solution:

Given: 4.5 moles $(NH_4)_2SO_4$
Wanted: # moles of H
Conversion: moles $(NH_4)_2SO_4$ to moles H
Conversion factor: $\frac{8 \text{ moles H}}{1 \text{ mole } (NH_4)_2SO_4}$

$$\frac{4.5 \text{ moles } (NH_4)_2SO_4}{} \left| \frac{8 \text{ moles H}}{1 \text{ mole } (NH_4)_2SO_4} \right. = 36 \text{ mole H}$$

How many moles of ammonium sulfate are in 32.0 g of $(NH_4)_2SO_4$?
Given: 32.0 g $(NH_4)_2SO_4$
Wanted: moles $(NH_4)_2SO_4$
Conversion Path: g $(NH_4)_2SO_4$ to moles $(NH_4)_2SO_4$
Conversion Factors: $\frac{132 \text{ g } (NH_4)_2SO_4}{1 \text{ mole } (NH_4)_2SO_4}$

Solution:

$$\frac{32.0 \text{ g } (NH_4)_2SO_4}{} \left| \frac{1 \text{mole } (NH_4)_2SO_4}{132 \text{ g } (NH_4)_2SO_4} \right. = 0.242 \text{ mole } (NH_4)_2SO_4$$

Calculate the number of H atoms in 39.6 g $(NH_4)_2SO_4$

Given: 39.6 g $(NH_4)_2SO_4$

Wanted: number of H atoms

Conversion Path: g $(NH_4)_2SO_4$ to moles $(NH_4)_2SO_4$ to moles H to atoms H

Conversion Factor: $\frac{132\text{ g }(NH_4)_2SO_4}{1\text{ mol }(NH_4)_2SO_4}$ $\frac{8\text{ mole H}}{1\text{ mol }(NH_4)_2SO_4}$ $\frac{6.02 \times 10^{23}\text{ atom H}}{1\text{ mole H}}$

Solution:

$$\frac{39.6\text{ g }(NH_4)_2SO_4}{} \left| \frac{1\text{ mole }(NH_4)_2SO_4}{132\text{ g }(NH_4)_2SO_4} \right| \frac{8\text{ mol H}}{1\text{ mol }(NH_4)_2SO_4} \left| \frac{6.02 \times 10^{23}\text{atom H}}{1\text{ mole H}} \right.$$