Chem 111

Lecture 6

Announcements

- Oct 4th is your first exam. Two weeks.

- Practice Exams:
http://courses.umass.edu/chem111-bbotch/ExamInfo.html

- Disability Services

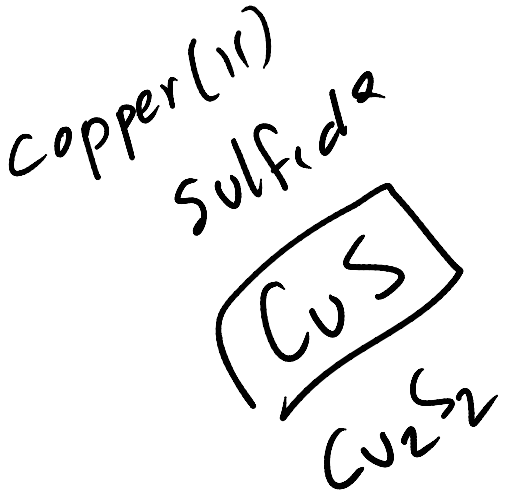
2 week ahead

Homework

- Start reading Chapter 3
- OWL online homework.

Recap

- Finished up formulas
- Ions
- Predicting monatomic ions
- List of Polyatomic ions
- Ionic compounds
- Naming



Mole

A **mole** is defined as the amount of matter that contains as many objects (atom, molecules, etc) as the number of atoms in exactly 12 g of ^{12}C.

Avogadro's Number = 6.0221367 x 10^{23}

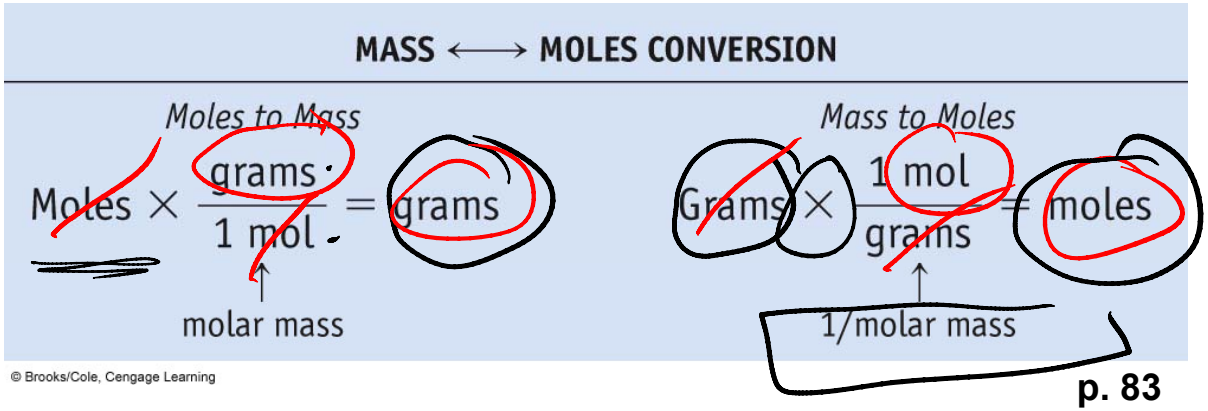
1 mol ^{12}C atoms = 6.02 x 10^{23} ^{12}C atoms
1 mol H_2O molecules = 6.02 x 10^{23} H_2O molecules
1 mol Na^+ ions = 6.02 x 10^{23} Na^+ ions

Molar Mass

Molar Mass is the quantity in grams numerically equal to its atomic (or formula) weight.

One ^{12}C atom weighs 12 u; 1 mol ^{12}C weighs 12 g
One ^{24}Mg atom weighs 24 u; 1 mol ^{24}Mg weighs 24 g

M of ^{24}Mg is 24.0 g/mol
M of Mg is 24.3 g/mol



p. 83

Formula Weight

The **Formula Weight** of a substance is the sum of the atomic weights of each atom in its chemical formula.

H_2SO_4

FW = 2(AW of H) + (AW of S) + 4 (AW of O)
= 2(1.0 u) + (32.0 u) + 4 (16.0)
= 98.0 u

One H_2SO_4 molecule weighs 98.0 u; 1 mol H_2SO_4 weighs 98.0 g

M of H_2SO_4 is 98.0 g/mol

Percent Composition

Percent Composition – the percentage by mass contributed by each element in a substance.

Sucrose – table sugar - $C_{12}H_{22}O_{11}$

1. Calculate the formula weight of the molecule.

12 C atoms = 12 (12.0 u) = 144.0 u
22 H atoms = 22 (1.0 u) = 22.0 u
11 O atoms = 11 (16.0 u) = 176.0 u

342.0 u = FW

So the FW of $C_{12}H_{22}O_{11}$ is 342.0 u

Percent Composition

2. So the FW of $C_{12}H_{22}O_{11}$ is 342.0 u

$$\frac{(Atoms\ of\ elements)(AW)}{FW\ of\ compound}\ x\ 100$$

$$\%\ C = \frac{(12)(12.0\ u)}{342\ u}\ x\ 100 = 42.1\%$$

$$\%\ H = \frac{(22)(1.0\ u)}{342\ u}\ x\ 100 = 6.4\%$$

$$\%\ O = \frac{(11)(16.0\ u)}{342\ u}\ x\ 100 = 51.5\%$$

100%

Empirical Formula from PC

Some chemical analysis only give you the percentage of each element and you have to figure out the empirical formula.

Ascorbic Acid contains 40.92 % C, 4.58 %H and 54.5 %O by mass.
Let's figure out its empirical formula.

1. Assume you have a 100 g of the substance.

That means you have:

40.92 g of Carbon
4.58 g of Hydrogen
54.5 g of Oxygen

Empirical Formula from PC

2. Calculate the number of moles of each element in 100g of compound

40.92 g of Carbon
4.58 g of Hydrogen
54.5 g of Oxygen

$$(40.92\ g\ C)\left(\frac{1\ mol\ C}{12.01\ g\ C}\right) = 3.407\ mol\ C$$

$$(4.58\ g\ H)\left(\frac{1\ mol\ H}{1.008\ g\ H}\right) = 4.54\ mol\ H$$

$$(54.50\ g\ O)\left(\frac{1\ mol\ O}{16.00\ g\ O}\right) = 3.406\ mol\ O$$

Empirical Formula from PC

2. Determine the simplest whole-number ratio of moles by dividing each number by the smallest number of moles.

3.407 mol C
4.54 mol H
3.406 mol O

$C_1 H_{1.33} O_1$

1 : 1.25 : 1

4 : 5 : 4

$$C: \frac{3.407}{3.406} = 1 \qquad H: \frac{4.54}{3.406} = 1.33 \qquad O: \frac{3.406}{3.406} = 1$$

So the C:H:O ratio is 1: 1.33: 1
But we need integer numbers so if we multiply by 3, we get 3:4:3

Thus the empirical formula of Ascorbic Acid is $C_3H_4O_3$

Empirical Form. ≠ Molecular Form.

Empirical formula of Ascorbic Acid is $C_3H_4O_3$

The molecular formula will always be a whole-number multiple of the empirical formula.

This multiple can be found by comparing the empirical formula weight to the molecular formula weight.

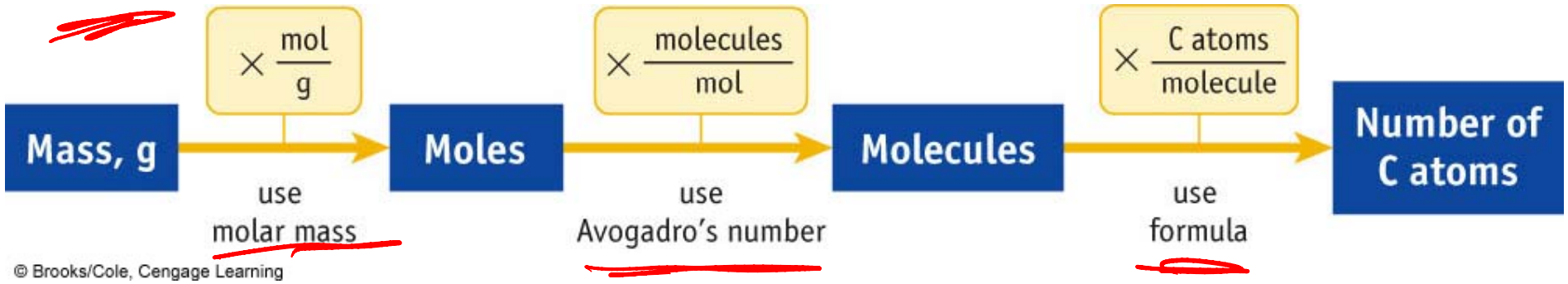
$C_3H_4O_3$ = 3 (12.0 u) + 4 (1.0 u) + 3 (16.0 u) = 88.0 u

And if I tell you that the formula weight of Ascorbic Acid = 176 u

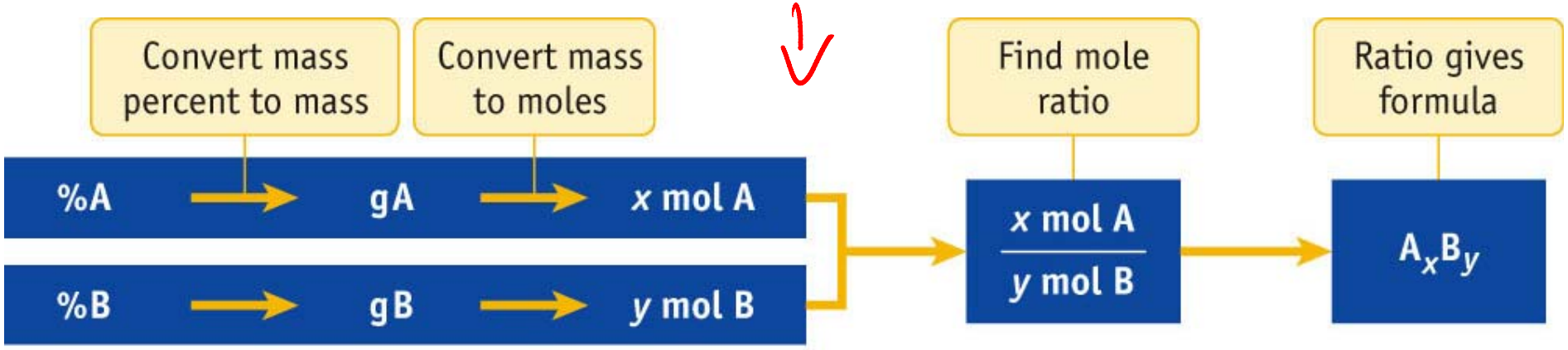
$$\frac{176}{88.0} = 2$$

Molecular Formula = $C_6H_8O_6$

Get Comfortable



Example 2-7, p. 87



p. 90

Hydrates/ Solvated Crystals

Often times when you get a compound the solvent will get trapped in the lattice.

Blue = $CoCl_2$
Pink = $CoCl_2 \bullet 6H_2O$

Let's Practice

Calculate the percentage of nitrogen (by mass) in $Ca(NO_3)_2$.

Let's Practice

Calculate the number of C atoms in 0.350 mol of $C_6H_{12}O_6$

Let's Practice

Anti-freeze, ethylene glycol, is composed of 38.7% carbon, 9.7% hydrogen and 51.6% oxygen by mass. Its molar mass is 62.1 g/mol. What is its molecular formula?

Chemical Equations

Concise way to represent chemical reactions.

$2\ H_2(g)\ +\ O_2(g)\ \rightarrow\ 2H_2O(l)$

"+" = reacts with
→ = produces
Left of arrow = reactants
Right of arrow = products

Physical State
(g) = gas
(l) = liquid
(s) = solid
(*aq*) = aqueous

Balanced Chemical Equations

$2\ H_2(g) + O_2(g) \rightarrow 2H_2O(l)$

In normal chemical reactions (non-nuclear) atoms are neither created nor destroyed. An equal number of atoms of each type are found on both sides of the equation.