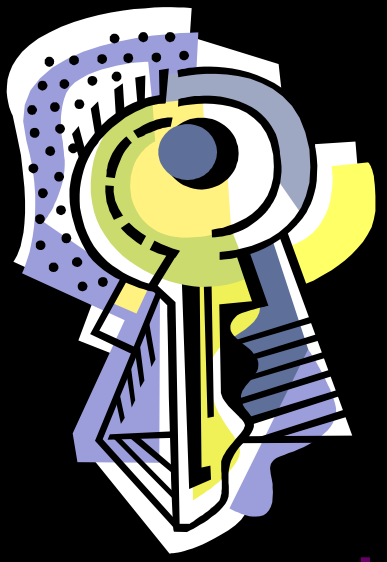
Unit 06 Outcomes

LPT

This unit starts the unit exam "inserts" …
separate problem solving questions for the unit exams.

Many of the outcomes are related to problem-solving.
The general schemes listed here should be translated to problem-solving skills gained by lots of practice with furnished problems.

Again, the key to success on the unit exams is success on the unit practice exams!



LPT

Given any one of the following (mass, grams, atoms) for a substance whose formula is known, calculate the other two:

Mass = sum of average atomic mass for each element

Average atomic mass taken from periodic table

$$\text{\# grams} \times \frac{1 \text{ mole}}{\text{molar mass g}} = \text{\# moles}$$

Molar mass = formula mass or molecular mass in grams

$$\text{\# moles} \times \frac{6.02 \times 10^{23} \text{ atoms}}{1 \text{ mole}} = \text{\# atoms}$$

1 mol = 6.02×10^{23} atoms (or ions, molecules, or formula units)

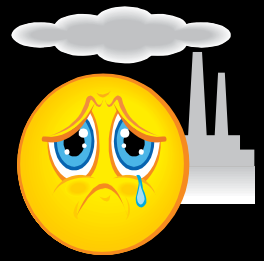
LPT

Determine the number of moles & the number of molecules in 9.68 g of CO_2

C: 1 x 12.01 = 12.01

O: 2 x 16.00 = 32.00

Molecular Mass = 44.01 g /mole



$$9.68 \text{ grams} \times \frac{1 \text{ mole}}{44.01 \text{ g}} = 0.0219950 \rightarrow 0.0220 \text{ moles}$$

$$9.68 \text{ grams} \times \frac{1 \text{ mole}}{44.01 \text{ g}} \times \frac{6.02 \times 10^{23} \text{ molecules}}{1 \text{ mole}} = 1.32 \times 10^{23} \text{ molecules}$$

LPT

Define the term percentage.

Percent (%) = parts per hundred

$$\% A = \frac{\text{amount A}}{\text{total A}} \times 100$$

Mass percent = amount in grams

Mole percent = amount in moles

Calculate % composition of an element from chemical formula

Write the formula

Count atoms, multiply # atoms x atomic mass

Sum & Round to get formula mass

$$\% A = \text{amount A} / \text{total compound mass} \times 100$$

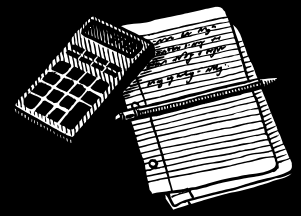
LPT

Determine the % composition of each element in CaI_2

Ca: 1 x 40.08 = 40.08

I: 2 x 126.9 = 253.8

Formula Mass = 293.88 ➔ 293.9 g / mole



% Ca: $\frac{40.08}{293.9}$ x 100 = 13.64 % I: $\frac{253.9}{293.9}$ x 100 = 86.39

Calculate the percentage composition of a compound given laboratory data indicating the number of grams of each element which reacted to form the compound.

For mass (weight) percent:
Each element
Mass of the element / Total weight of all components

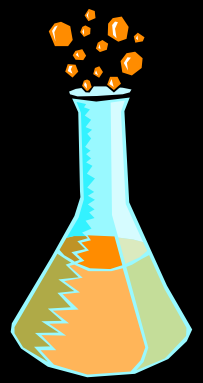
% is always

(Something / Total) x 100

LPT

The weight % composition if 8.89 g Al combine with 77.3 g Br is

Total grams is 8.89 + 77.3 = 86.19 ➔ 86.2 g



Weight percent Al = 8.89 g/ 86.2 g x 100 = 10.23

Weight percent Br = 77.3 g/ 86.2 g x 100 = 89.68

LPT

For any known formula is known, given the mass of the sample, calculate the mass of any element in the sample.

Determine Molar Mass
Then, determine mass of each element present

$$\text{\# total grams} \times \frac{1 \text{ mole}}{\text{molar mass(g)}} = \text{\# moles compound}$$

Determine grams for each wanted element

$$\text{\# moles compound} \times \frac{\text{ave mass element g}}{1 \text{ mole}} = \text{\# grams element}$$

LPT

The mass in grams of Al in a 62.9 g sample of Al_2O_3 is

Formula mass aluminum oxide:

Al = 2 x 26.98 = 53.96

O = 3 x 16.00 = 48.00

Molar mass = 101.96

Conversion to grams Al (2 moles Al per formula mass)

$$62.9\ g\ Al_2O_3 \times \frac{1\ mole\ Al_2O_3}{101.96\ g} \times \frac{2\ moles\ Al}{1\ mole\ Al_2O_3} \times \frac{26.98\ g}{1\ mole\ Al} = 33.3\ g\ Al$$

LPT

For known formula, given the mass of any element in the sample, calculate the mass of the sample or of any other element in the sample.

Determine Molar Mass for the compound
Determine mole percent of element whose mass was given
Then:

Mole percent = element of interest / total molar mass x 100

LPT

Determine the mass of MgO that contains 19.2 g oxygen.

Mg: 1 x 24.31 = 24.31
O: 1 x 16.00 = 16.00
Formula Mass = 40.31 g / mole

% oxygen for all samples of MgO

$$\frac{16.00}{40.31} \times 100 = 39.69$$

All samples, including the problem sample contain 39.69 % oxygen, so

$$0.3969 = \frac{19.2 \text{ g oxygen}}{\text{Total mass}}$$

$$\text{Total mass} = \frac{19.2 \text{ g}}{0.3939} = 48.7 \text{ g}$$

For these problems,
it is often more convenient to keep the % as a decimal
Saves having to both multiply and divide by 100

LPT

Define the term "empirical formula."

Empirical = lowest (simplest) integer ratio of elements
= determined empirically (by experiment)
= maybe generalized (like C_nH_{n+2})
= formulas for ionic compounds
= RATIO of elements present

$C_4H_9O_2$	Empirical
$C_4H_{10}O_2$	Chemical
NaCl	Empirical
C_nH_{n+2}	Empirical
$C_6H_{12}O_6$	Chemical
C_2H_5OH	Chemical

LPT

Calculate the empirical formula of a compound given its percentage composition

When given elemental %, assume 100 grams total
Get weights from the Periodic Table

Then, for each element

$$\%\ \text{as g} \times \frac{1\ \text{mole}}{\text{atomic mass element g}} = \#\ \text{mole of each element}$$

Determine Mole Ratio: ratio gives formula

$$\frac{\#\ \text{moles element 1}}{\#\ \text{moles element 2}} = \text{molar ratio}$$

Subscripts in formula correspond to molar ratios

LPT

Determine the empirical formula for a compound that is 18.25 % carbon, 0.77 % hydrogen and 80.99 % chlorine.

				Mole Ratio	
C:	18.25 g x	$\frac{1 \text{ mole}}{12.01 \text{ g}}$	= 1.520	2	
H:	0.77 g x	$\frac{1 \text{ mole}}{1.008 \text{ g}}$	= 0.760	1	➔ C_2HCl_3
Cl:	80.99 g x	$\frac{1 \text{ mole}}{35.45 \text{ g}}$	= 2.284	3	

Calculate the empirical formula for a compound given grams of each elements present

Determine # Moles of each element : ratio gives formula
(Use Periodic Table to get atomic weights of the elements)

For Each Element in the compound

$$\#\ \text{given g} \times \frac{1\ \text{mole}}{\text{molar mass g}} = \#\ \text{moles of element}$$

Determine Mole Ratio: ratio gives formula

$$\frac{\#\ \text{moles element 1}}{\#\ \text{moles element 2}} = \text{molar ratio}$$

Subscripts in formula correspond to molar ratios

LPT

What is the empirical formula of a substance that contains: 1.39 grams sodium, 7.69 grams iodine, and 2.90 grams oxygen?

(Mole Ratio … diving all by 0.0605)

Na: $1.39\ g \times \frac{1\ mole}{22.99\ g} = 0.0605\ moles$ 1

I: $7.69\ g \times \frac{1\ mole}{126.90\ g} = 0.0606\ moles$ 1 ➔ $NaIO_3$

O: $2.90\ g \times \frac{1\ mole}{16.00\ g} = 0.181\ moles$ 3

LPT

Define terms & symbols:

Reactant = starting material (left of arrow)
Product = result of reaction (right of arrow)
Coefficient = number of molecules (moles) in the equation
State Symbols:

(s) = solid state; typically precipitant
(1) = liquid state
(g) = gaseous state
(aq) = aqueous; dissolved in water

LPT

Identify the reactants & products in a chemical equation

For general reaction A + B ➔ C + D

Reactants (Left of arrow) = A and B
Products (Right of arrow) = C and D

Translate English sentence into a chemical equation; & visa versa

For general reaction A + B ➔ C + D

A and B react to form C and D
A plus B yields C plus D

The reaction KOH + HBr ➔ KBr + H_2O translates to:

Potassium hydroxide and hydrobromic acid produces potassium chloride and water

LPT

Differentiate balanced & unbalanced equations

For general reaction A + B ➔ C + D

Unbalanced = # atoms of each element
not equal for reactants & products

Balanced = # atoms of each element
the same for both starting materials & products

Calculate # of atoms of an element in a reactant or product, given its chemical formula and coefficient in a chemical equation.

Count atoms for each element present
(Multiply everything inside a parenthesis by the subscript)
Multiply # atoms in compound by the coefficient
Multiply total # atoms for each element x atomic weight
Sum & round

LPT

Balanced or unbalanced?

$Al + 3\ HBr \rightarrow AlBr_3 + 3\ H_2$ Unbalanced

$2Al + 6\ HBr \rightarrow 2\ AlBr_3 + 3\ H_2$ Balanced

$C_2H_6 + 7\ O_2 \rightarrow 2\ CO_2 + 3\ H_2O$ Unbalanced

$2\ C_2H_6 + 7\ O_2 \rightarrow 4\ CO_2 + 6\ H_2O$ Balanced

The total number of oxygen atoms in $Ga_2(SO_3)_3$
There are three SO_3 groups, so total oxygen atoms is 9

The total number of oxygen atoms in $4\ Fe_3(PO_4)_2$
There are two PO_4 groups, so total oxygen atoms is 8
But, there are 4 formula units, so total oxygen is 32

LPT

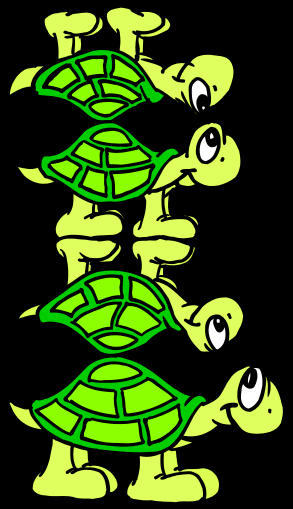
Balance by inspection, an unbalanced chemical equation

Start with correct chemical formulas
Work with whole number coefficients
(Trial and error until atoms on both sides are equal)

Bottom line:
No fixed rule … every reaction is different
Requires practice to develop balancing skills

My two guidelines:
- Start with a metal or most complex reaction material
- Save water (or diatomic gasses) for last step

LPT



Balance the Following

$2\ H_2 + O_2 \rightarrow 2\ H_2O$

$N_2 + 3\ H_2 \rightarrow 2\ NH_3$

$3\ CaCl_2 + 2\ Na_3PO_4 \rightarrow Ca_3(PO_4)_2 + 6\ NaCl$

$S_8 + 24\ F_2 \rightarrow 8\ SF_6$

$N_2O_5 + H_2O \rightarrow 2\ HNO_3$

$2\ Al + 3\ CuO \rightarrow Al_2O_3 + 3\ Cu$

$2\ KClO_3 \rightarrow 2\ KCl + 3\ O_2$

$H_2SO_4 + 2\ KOH \rightarrow K_2SO_4 + 2\ H_2O$

$2\ AgNO_3 + K_2CrO_4 \rightarrow Ag_2CrO_4 + 2\ KNO_3$

$C_3H_8 + 5\ O_2 \rightarrow 3\ CO_2 + 4\ H_2O$

LPT

Identify the following types of reactions:

Combination (Synthesis) Reactions

$A + X \rightarrow AX$

Decomposition Reactions

$AX \rightarrow A + X$

Burning or Complete Combustion

$C_xH_yO_z + O_2 \rightarrow CO_2 + H_20$

Single Replacement

$A + BX \rightarrow AX + B$ **Or** $Y + BX \rightarrow BY + X$

Double Replacement Reactions

$A^+X^- + B^+Y^- \rightarrow A^+Y^- + B^+X^-$

Neutralization (special case of double sisplacement)

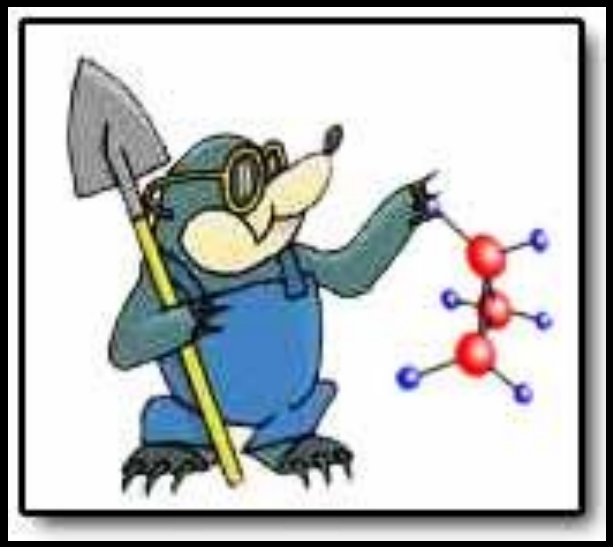
Acid + Base → Salt + Water

Classify The Following Reactions:

$Zn + 2\,HCl \rightarrow ZnCl_2 + H_2$	Single Replacement
$2\,C_2H_6 + 7\,O_2 \rightarrow 4\,CO_2 + 6\,H_2O$	Complete Combustion
$3\,Mg + N_2 \rightarrow Mg_3N_2$	Combination or Synthesis
$HBr + NaOH \rightarrow H_2O + NaBr$	Neutralization
$Ba(NO_3)_2 + Na_2SO_4 \rightarrow 2\,NaNO_3 + BaSO_4$	Precipitation
$Cl_2 + ZnBr_2 \rightarrow ZnCl_2 + Br_2$	Single Replacement
$2\,C_2H_6 + 7\,O_2 \rightarrow 4\,CO_2 + 6\,H_2O$	Complete Combustion
$H_2SO_3 \rightarrow H_2O + SO_{2\,(g)}$	Gas Forming
$Al_2(CO_3) \rightarrow Al_2O_3 + 3\,CO_2$	Decomposition

LPT

Remember to Think Moles Not Grams



& Keep track of units!

LPT

Sample Insert Exam

(2 pts) How many moles of $Al_2(CO_3)_3$ are in 83.25 grams of the compound?

Given grams, need moles ➔ need molar mass for conversion

Al: 2 x 26.98 = 53.96

C: 3 x 12.01 = 36.03

O: 9 x 16.00 = 144.0

Molar Mass = 233.99 ➔ 234.0 g / mole

$$82.35 \text{ grams } Al_2(CO_3)_3 \times \frac{1 \text{ mole } Al_2(CO_3)_3}{234.0 \text{ g}} = 0.3519 \text{ moles}$$

LPT

(3 pts) Calculate the % composition of $Mn(NO_2)_2$

Mn: 1 x 54.94 = 54.04
N: 2 x 14.01 = 28.02
O: 4 x 16.00 = 64.00
Molar Mass = 146.06 g / mole

% Mn = 54.04 / 146.06 x 100 = 37.00
% N = 28.02 / 146.06 x 100 = 19.18
% O = 64.00 / 146.06 x 100 = 43.82

LPT

(3 pts) What is the empirical formula of a substance containing 3.450 g calcium, 2.418 g silicon, and 4.132 g oxygen?

molar ratio

Ca: 3.450 g x $\frac{1 \text{ mole}}{40.08 \text{ g}}$ = 0.0861 moles **1**

Si: 2.418 g x $\frac{1 \text{ mole}}{28.09 \text{ g}}$ = 0.0861 moles **1**

O: 4.132 g x $\frac{1 \text{ mole}}{16.00 \text{ g}}$ = 0.2583 moles **3**

$CaSiO_3$

LPT

Balance & Classify the following equations:

$H_2SO_{4\,(aq)} + 2\,NH_{3\,(aq)} \rightarrow (NH_4)_2SO_{4\,(aq)}$

Combination

$2\,C_6H_{14\,(l)} + 19\,O_{2\,(g)} \rightarrow 12\,CO_{2\,(g)} + 14\,H_2O_{\,(g)}$

Complete Combustion

LPT