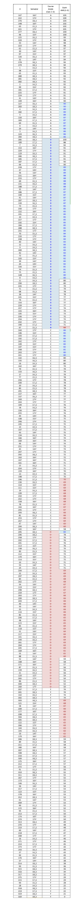
CHAPTER 8
CHEMICAL COMPOSITION
(STOICHIOMETRY I)

CHAPTER 15 - part
(MOLARITY)

CHAPTER 9
CHEMICAL QUANITIES
(STOICHIOMETRY II)

# 8,9,15

¿So, at the end of the day, am I going to pass this course?



| COURSE GRADE vs. EXAM(1–2) AVERAGE | | |
|---|---|---|
| FINAL COURSE GRADE (Past Courses) | Exams1–2 AVERAGE: Range Max | Exams1–2 AVERAGE: Range Min |
| A | 105 | 86 |
| B | 100 | 63 |
| C | 86 | 58 |
| D | 83 | 50 |
| F | 74 | 0 |
| n = | 319 | 319 |

# GROUP PROJECT

# CHAPTERS 8 & 9
# CHEMICAL COMPOSITION & QUANTITIES (STOICHIOMETRY)

| TOPIC | CH8 | CH9 |
|---|---|---|
| 1. stoichiometry calc | 205–224 | 249-263 |
| 2. limiting reagents | — | 264-272 |
| 3. % yield | 225–226 | — |
| 4. % composition | 227–end | — |
| 5. det'n formulas | — | 273-end |

# Stoichiometry Background

Stoichiometry = measuring in the correct proportions

(weighs)
macroscopic

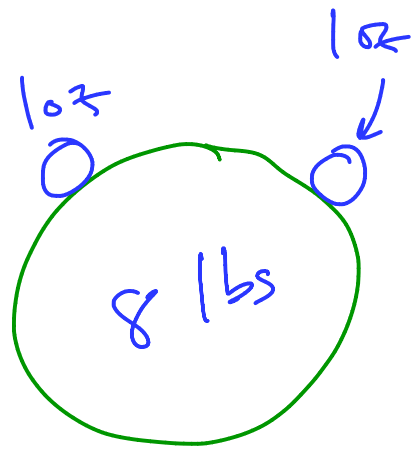
□ g    128g    □ g

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

H–H   O–O
H–H

microscopic
(count)

Mother nature COUNTS; but we WEIGH



## “Houston, we have a problem.”

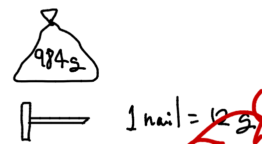
To perform experiments, we need to be able to COUNT molecules, and to SCALE the amounts up enough so we can see (measure) them. . . but we can’t see molecules, much less count them out.

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

(2) Scale Up

(1) Count-by-Weighting

$$small\ scale\ up\ factor = \frac{12\ items}{dozen}$$




$$\frac{\square\ nails}{1} = \frac{1\ nail}{12\ g} \times 984\ g = 84$$

**Scale-up Factor: Avogadro’s Number (6.02E23)**

$$scale\ up\ factor = \frac{6.02E23\ items}{mole} = \frac{6.02\times10^{23}\ items}{mole}$$

← Count-by-weighing →

↑ Scale-up ↓

1 atom C — 12 amu

$6.02\times10^{23}$ ↓ ↓

1 mol C — 12 g

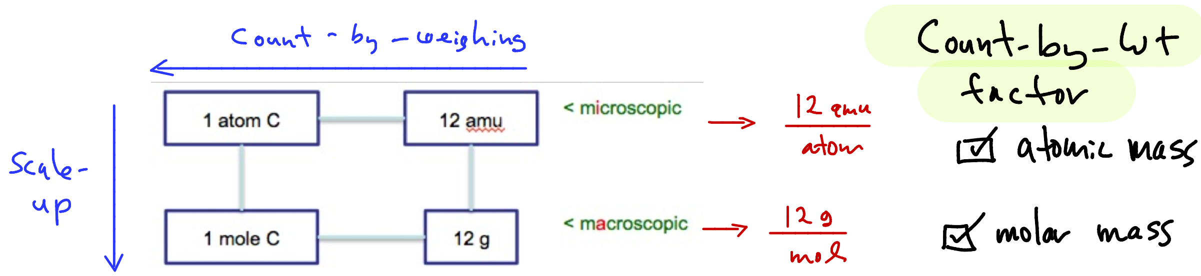
$\left(\frac{12\ g}{1\ mol}\right)$ $\left(\frac{1\ mol}{12\ g}\right)$

**Count-by-Weight Factor: Molar Mass**

↳ mass of 1 mole of a substance

↳ mass of 6.02E23 parts of a substance

# Scale-Up and Count-by-Weighing:
# The Periodic Chart & Moles & Molar Masses & Avogadro's Number




**Scale-up Factor: Avogadro's Number (6.02E23)**

$$scale\ up\ factor = \frac{6.02E23\ items}{mole} = \frac{6.02 \times 10^{23}\ items}{mole}$$

**Count-by-Weight Factor: Molar Mass**

↳ mass of 1 mole of a substance
↳ mass of 6.02E23 parts of a substance

↓ ASIDE ↓

## Just how large is a ‘mole’ of something

$$\begin{aligned} 1\, mole\, of\, stacked\, pennies &= to\, moon\, and\, back \ldots 100\, million\, times \\ 1\, mole\, of\, seconds &= 1\, million\, ages\, of\, the\, supposed\, age\, of\, the\, universe \\ 1\, mole\, of\, human\, cells &= 6\, billion\, people \\ 1\, mole\, of\, sand &= cover\, entire\, USA \ldots 2.4\, inches\, deep \end{aligned}$$

$$?\,age = \frac{6.02E23\ s}{} \bullet \frac{1\ \text{min}}{60\ s} \bullet \frac{1\ hr}{60\ \text{min}} \bullet \frac{1\ day}{24\ hr} \bullet \frac{1\ yr}{365\ day} \bullet \frac{1\ age}{2E16\ yr} = 954{,}465\ ages$$

$$?\,humans = \frac{6.02E23\ cells}{} \bullet \frac{1\ body}{100E12\ cells} = 6E9\ humans$$

[100*trillion*] [6*billion*]

$$?\,in = \frac{6.02E23\ grains}{} \bullet \frac{10^{-12}\ m^3}{1\ grain} \bullet \frac{1\ USA}{10^{13}\ m^2} \bullet \frac{100\ cm}{1\ m} \bullet \frac{1\ in}{2.54\ cm} = 2.37\ in$$

FACTOIDS

① "Mole" derives from word meaning "mass," but it refers to the number of "particles" or "bits" or "pieces" or "entities" of mass

② Mole is one of 7 fundamental SI units

③ Definition: amount of material "discrete entities" as the number in exactly 12 g of Carbon of Carbon-12

④ $N_A$ = AN = Avagadro's Number = $6.022 \times 10^{23}$

$$\frac{6.022\ x\ 10^{23}\ entities}{1\ mol} \quad or \quad \frac{1\ mol}{6.022\ x\ 10^{23}\ entities}$$

⑤ Mole is just a number with a name, just like the number 12

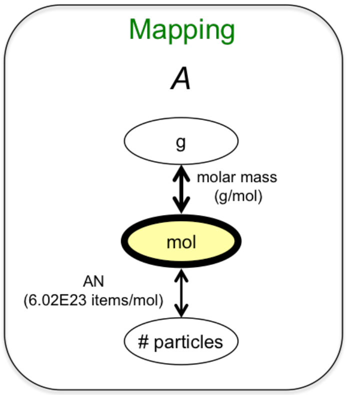
$$\frac{6.022\ x\ 10^{23}\ entities}{1\ mol} \quad vs \quad \frac{12\ entities}{1\ dozen}$$

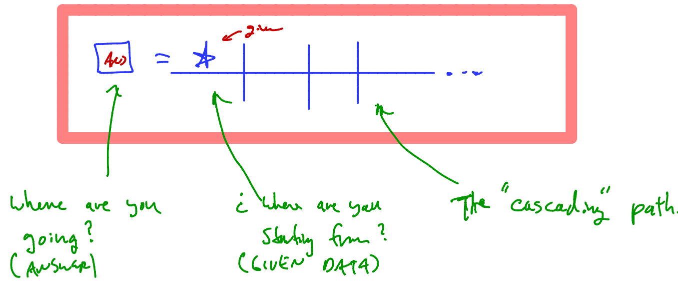
One amu ~ mass (proton or neutron)
DEF = exactly 1/12-th of the mass of one carbon-12 atom (1 amu = 1.6604e-24 g) (p76/84)

A mole is defined as the amount of substance containing the same number of discrete entities (such as atoms, molecules, and ions) as the number of atoms in a sample of pure 12 C weighing exactly 12 g.

↑ ASIDE ↑

## “g–mole–particles” Calculations




## Stoichiometric Calculations: The most important “core concept” of this course!

$$\frac{\square}{1} = \frac{\star}{\rule{2em}{0.4pt}} \cdot \frac{\rule{2em}{0.4pt}}{} \cdot \frac{\rule{2em}{0.4pt}}{} = keep\ going\ until\ unit\ on\ right\ is\ same\ as\ the\ unit\ on\ the\ left$$

let the MAP guide you along the Dimensional Analysis path

# USING MOLAR MASS AND AVOGADRO'S NUMBER IN "g–mole–particles" CALCULATIONS

(EX) g —> atoms

¿How many copper atoms are in 5.00 g of copper wire?

[Whitten ex 3.5]

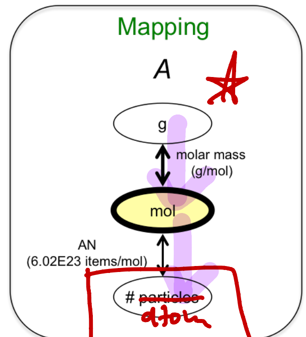
$$\frac{\square\ atoms\ Cu}{1} =$$

$$\frac{\square\ atoms\ Cu}{1} = \frac{5.00\ g\ Cu}{1} \cdot$$

$$\frac{\square\ atoms\ Cu}{1} = \frac{5.00\ g\ Cu}{1} \left(\frac{1\ mole\ Cu}{63.55\ g\ Cu}\right)$$

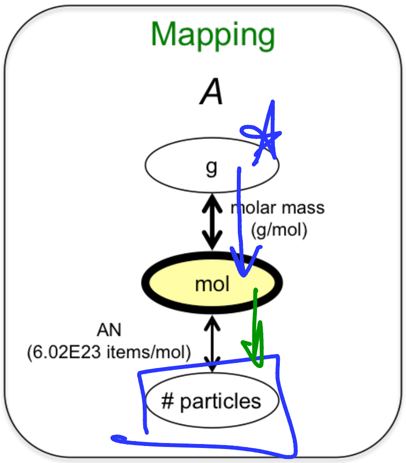
$$\frac{\square\ atoms\ Cu}{1} = \frac{5.00\ g\ Cu}{1} \cdot \frac{1\ mole\ Cu}{63.55\ g\ Cu} \cdot \frac{6.023E23\ atoms\ Cu}{1\ mol\ Cu}$$

$$\frac{\square\ atoms\ Cu}{1} = \frac{5.00\ g\ Cu}{1} \cdot \frac{1\ mole\ Cu}{63.55\ g\ Cu} \cdot \frac{6.023E23\ atoms\ Cu}{1\ mol\ Cu} = \frac{4.74E22\ atoms\ Cu}{1}$$



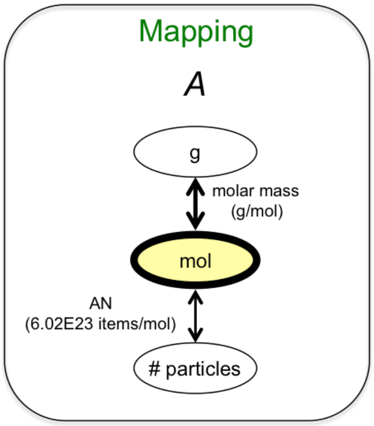
## Flight Path Analogy

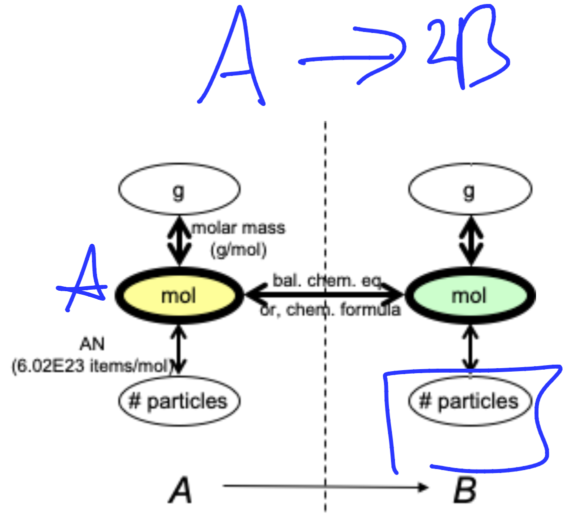
- start @ 5.00 g,Cu
- depart g,Cu —> arrive mol,Cu
- depart mol,Cu —> arrive # particles, Cu (your destinaton)



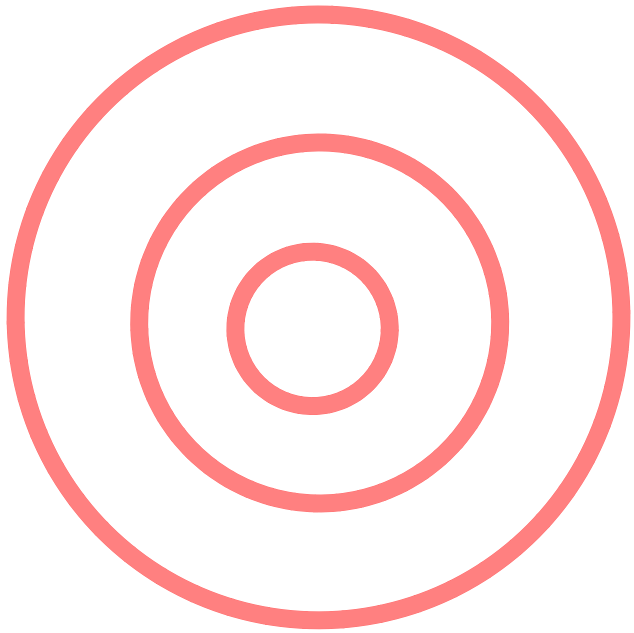

$$\frac{\square\, atoms\ Cu}{1} = \frac{5.00\ g\ Cu}{1} \cdot \frac{1\ mole\ Cu}{63.55\ g\ Cu} \cdot \frac{6.023E23\ atoms\ Cu}{1\ mol\ Cu} = \frac{4.74E22\ atoms\ Cu}{1}$$

# What the future holds . . .



*Lecture*



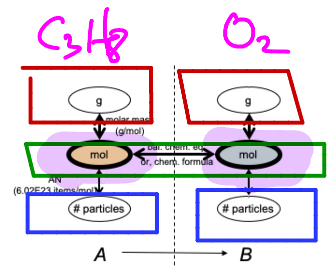
*Target*

## “mole-to-mole” Calculations (stoichiometry across an equation)

(EX) Mole → Mole Calculation

Calculate the number of moles of oxygen required to react exactly with 4.30 moles of propane, C3H8, in the reaction described by the following balanced equation:

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




$$\frac{\square\ mol_{O_2}}{1} = \frac{4.30\ mol_{C_3H_8}}{1} \times \frac{5\ mol_{O_2}}{1\ mol_{C_3H_8}} = \frac{21.5\ mol_{O_2}}{1}$$

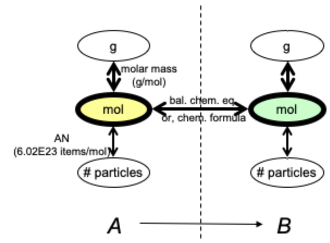
(EX) g,A → g,B

¿Calc amount, in grams, of water produced from 128 g $O_2$?

128 g    144 g

$$2\,H_2 + 1\,O_2 \rightarrow 2\,H_2O$$

mol




$$\frac{\square\ g,w}{1} = \frac{128\,g\,O_2}{32\,g\,O_2} \cdot \frac{1\,mol\,O_2}{1\,mol\,O_2} \cdot \frac{2\,mol\,w}{1\,mol\,O_2} \cdot \frac{18\,g,w}{1\,mol\,w}$$

2 H = 2(1)
1 O = 1(16)
$H_2O$ = 18

$O_2$
2(O) = 2(16) = 32

MM, PC

word, PC, eq

$$\square\ g,_{H_2O} = \frac{128\ g,_{O_2}}{} \bullet \frac{1\ mol,_{O_2}}{32\ g,_{O_2}} \bullet \frac{2\ mol,_{H_2O}}{1\ mol,_{O_2}} \bullet \frac{18\ g,_{H_2O}}{1\ mol,_{H_2O}} = 144\ g,_{H_2O}$$

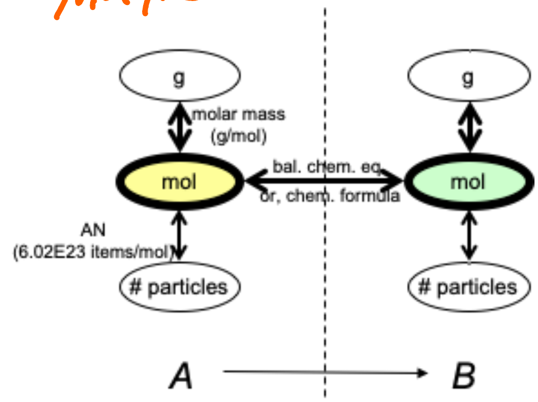
$H_2SO_4$

NaOH

(EX) g,B → g,A

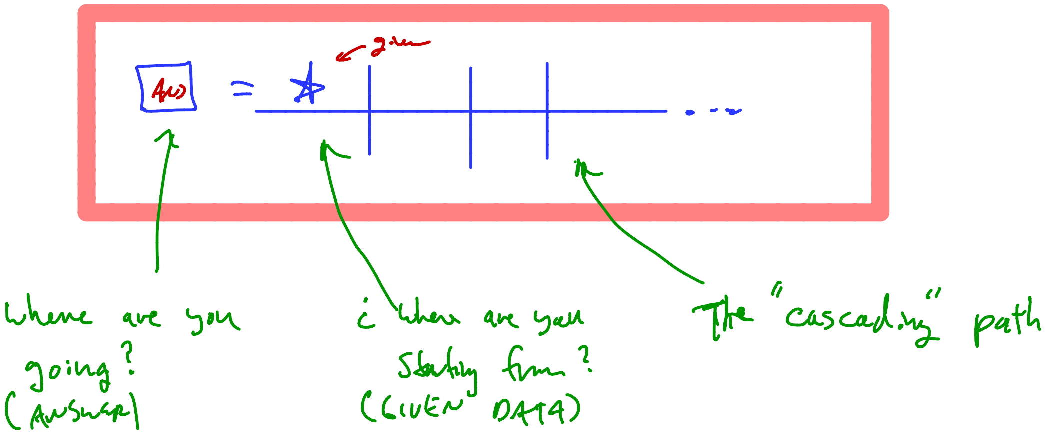
¿Calc grams of hydrogen that will react with 128 g $O_2$?

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




$$\square\; g_{,H_2} = \frac{128\,g_{,O_2}}{} \cdot \frac{1\,mol_{,O_2}}{32\,g_{,O_2}} \cdot \frac{2\,mol_{,H_2}}{1\,mol_{,O_2}} \cdot \frac{2\,g_{,H_2}}{1\,mol_{,H_2}} =$$ [redacted] 16 g $H_2$

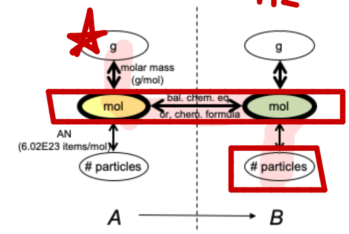
## General Approach for Solving Stoichiometry Problems via DA



(EX) g,A → molecules,B

¿Calc number of water molecules produced from 128 g $O_2$?

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




¿Calc number of water molecules produced from 128 g $O_2$?

$$\square\ molecules,_{H_2O} = \frac{128\ g,_{O_2}}{} \bullet \frac{1\ mol,_{O_2}}{32\ g,_{O_2}} \bullet \frac{2\ mol,_{H_2O}}{1\ mol,_{O_2}} \bullet \frac{6.02x10^{23}\ molecules,_{H_2O}}{1\ mol,_{H_2O}} = 4.82x10^{24}\ molecules,_{H_2O}$$

(EX) g,A → g,B

¿How many grams of MgO can be formed from the combustion of 42.2 g of Mg?

$$2\,Mg + O_2 \rightarrow 2\,MgO$$

$$\frac{\square\ g_{MgO}}{1} = \frac{42.2\ g_{Mg}}{1} \times \frac{1\ mol_{Mg}}{24.3\ g_{Mg}} \times \frac{1\ mol_{MgO}}{1\ mol_{Mg}} \times \frac{40.3\ g_{MgO}}{1\ mol_{MgO}} = \frac{70.0\ g_{MgO}}{1}$$

## % Yield

$$\% \text{ yield} = \frac{\text{experimental}}{\text{theoretical}} \bullet 100 \qquad \% \text{ yield} = \frac{\text{what you got}}{\text{what you should'a got}} \bullet 100$$

(EX) Calc % Yield

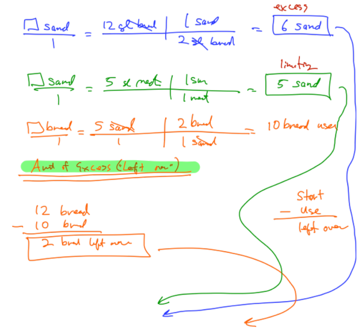
¿For the MgO reaction above, if you actually recover 33.7 g of MgO after running the experiments, what is your percent yield?

$$\% \text{ yield} = \frac{33.7\text{ g}}{70.0} \times 100 = 48.1\%$$

$$\% \text{ yield} = \frac{\text{experimental}}{\text{theoretical}} \bullet 100 = \frac{33.7\text{ g}}{70.0\text{ g}} \bullet 100 = 48.1\,\%$$

100 → (90%) → 90 → (50%) → 45 → (10%) → 4.5

## Limiting Reagent



2 bread + 1 meat → 1 sandwich

12 5 → □

$$\frac{\square \text{ sand}}{1} = \frac{12 \text{ bread}}{1} \left| \frac{1 \text{ sand}}{2 \text{ bread}} \right. = 6 \text{ sand}$$

$$\frac{\square \text{ sand}}{1} = \frac{5 \text{ meat}}{1} \left| \frac{1 \text{ sand}}{1 \text{ meat}} \right. = 5 \text{ sand}$$

## 3 Types of Limiting Reagent Problems

(i) determine limiting reagent
(ii) determine excess reagent
(iii) determine amount of excess reagent left over

(EX) Limiting Reagent
¿You have 5.00 g of manganese dioxide and 7.00 g of sulfuric acid.
(a) How much water can you make?

5.00g 7.00g

$$Mn0_2 + 2\ H_2SO_4 \rightarrow MnSO_4 + 2\ H_2O$$

(b) If one of the materials is in excess, how much of it is left over?

$\frac{\square \text{ g, W}}{1} = \frac{5.00 \text{ g, A}}{} \left| \frac{1 \text{ mol A}}{86.94 \text{ g A}} \right| \frac{2 \text{ mol W}}{1 \text{ mol A}} \left| \frac{18 \text{ g W}}{1 \text{ mol W}} \right| = 2.07 \text{ g W}$ excess

(calc)

$\frac{\square \text{ g, W}}{1} = \frac{7.00 \text{ g B}}{} \left| \frac{1 \text{ mol B}}{98.09 \text{ g B}} \right| \frac{2 \text{ mol W}}{2 \text{ mol B}} \left| \frac{18 \text{ g W}}{1 \text{ mol}} \right| = 1.28 \text{ g W}$ limit

(a) limiting = $H_2SO_4$

(b) excess = $MnO_2$

(c)

1(Mn) = 1(  )

2(O) = 2(16)

1 $MnO_2$   86.94 g

excess ↓   limit ↓

$\frac{\square \text{ g, } MnO_2}{1} = \frac{7.00 \text{ g } H_2SO_4}{1} \left| \frac{1 \text{ mol } H_2O}{98 \text{ g } H_2SO_4} \right| \frac{1 \text{ mol } MnO_2}{2 \text{ mol } H_2SO_4} \left| \frac{86.94 \text{ g } MnO_2}{1 \text{ mol } MnO_2} \right| =$

$= 3.10 \text{ g, } MnO_2$ USED

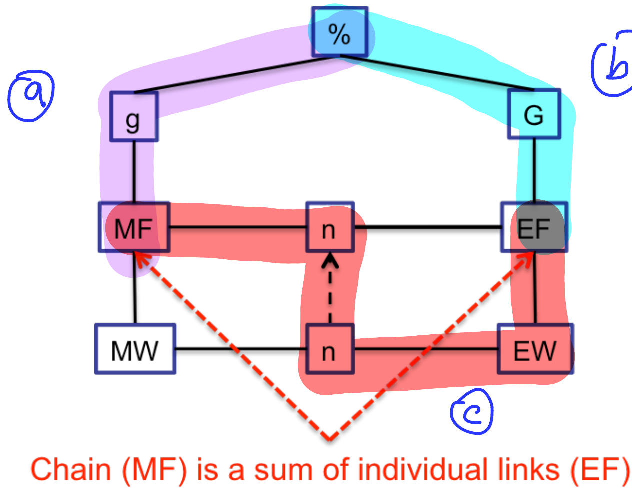
5.00 g ← amt started with

−3.10 g ← amt. used

1.90 g LEFT OVER ("EXCESS")

# Chemical Composition

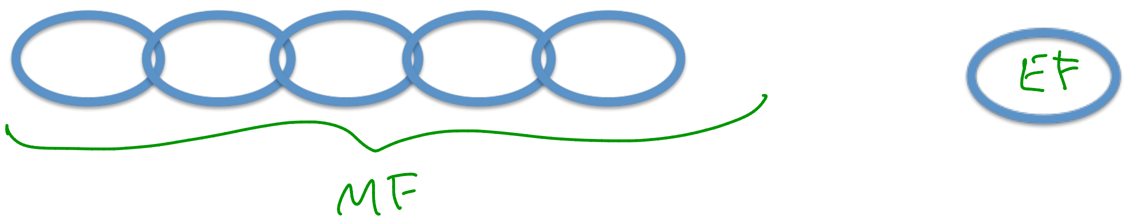
## Determining Empirical And Molecular Formulas

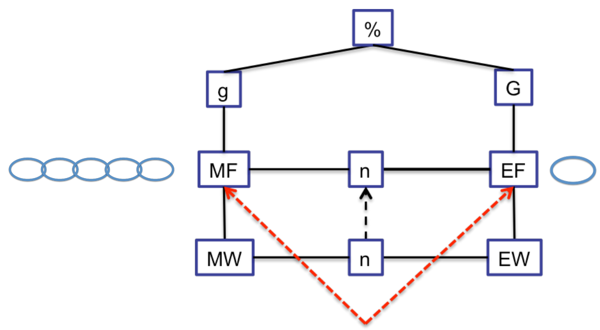



## Percent Composition — 3 types of questions

(i) Determining Percent Composition from Formula Mass
(ii) Deriving Empirical Formulas from Percent Composition
(iii) Derivation of Molecular Formulas

## Molecular vs. Empirical ("Simplest") Formula



$$\% = \frac{PART}{WHOLE} \times 100$$

$$\%H = \frac{2.0g}{34.0g} \times 100 = 5.9\%H$$

$$\%O = \frac{32.0}{34.0} \times 100 = 94.1\%O$$

H) $\frac{2 \text{ mol H}}{} \Big| \frac{1.0g\ H}{1 \text{ mol H}} = 2.0g\ H$

O) $\frac{2 \text{ mol O}}{} \Big| \frac{16.0g\ O}{1 \text{ mol O}} = 32.0g\ O$

1 $H_2O_2$ — 34.0g

$A_xB_yC_z$

TOTT #1 (assume 100g sample)

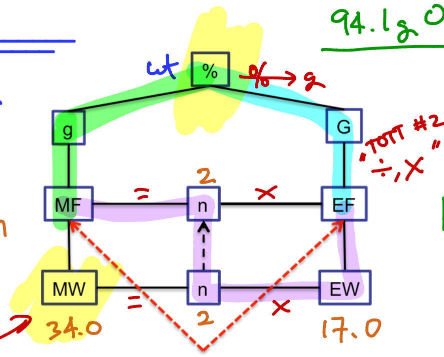
$\frac{5.9g\ H}{} \Big| \frac{1 \text{ mol H}}{1.0g\ H} = 5.9 \text{ mol H}$

$\frac{94.1g\ O}{} \Big| \frac{1 \text{ mol O}}{16.0g\ O} = 5.9 \text{ mol O}$

$H_{5.9}O_{5.9}$ → $\frac{5.9}{5.9}$ $\frac{5.9}{5.9}$

÷ smallest subscript

$H_1O_1$ → HO




Chain (MF) is a sum of individual links (EF)

HO

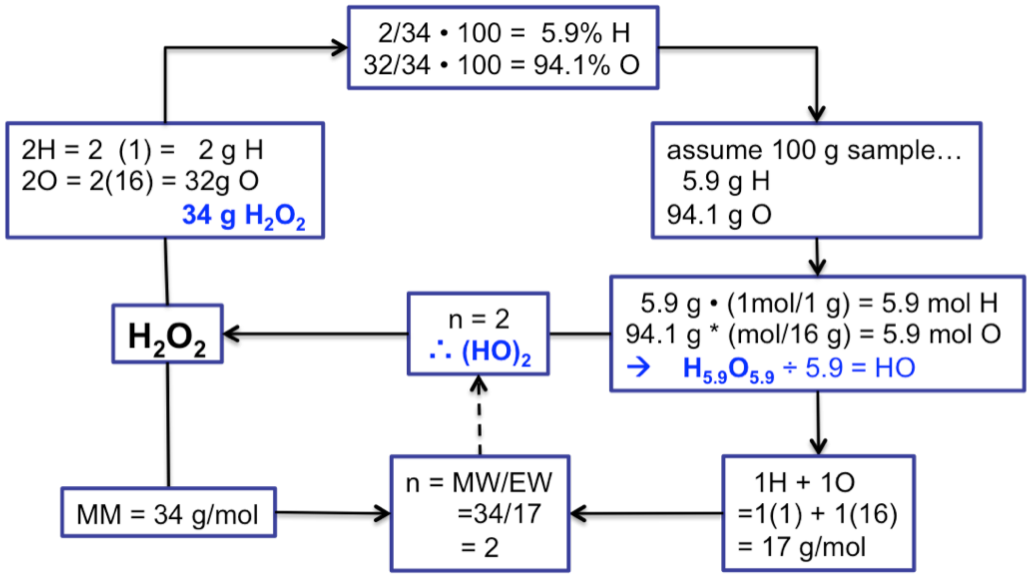
$1(H) = 1(1.0) = 1.0g$

$1(O) = 1(16.0) = 16.0g$

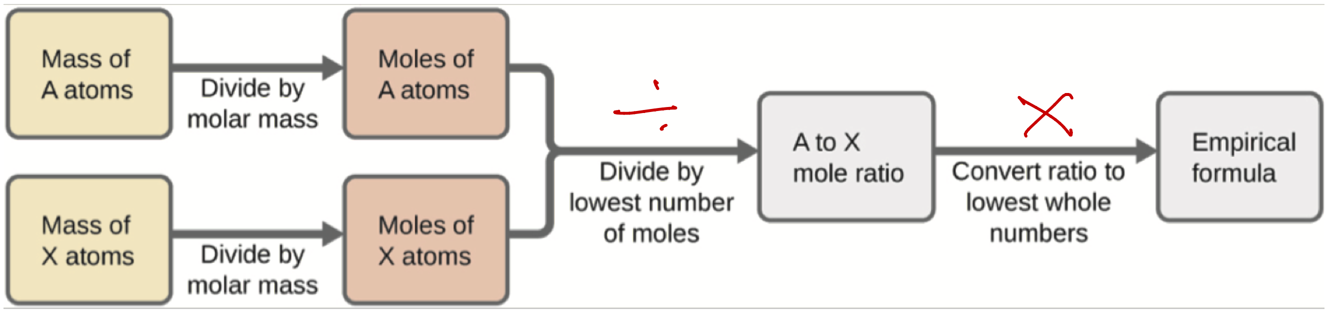
17.0g

$1\ H_2O_2$ ← $(HO)_n$ ← "$(HO)_2$" → $H_2O_2$

TOTT #3
"MW often given"
If MW given, often a "TYPE C" problem


2/34 • 100 = 5.9% H
32/34 • 100 = 94.1% O
2H = 2 (1) = 2 g H
2O = 2(16) = 32g O
34 g H2O2
assume 100 g sample…
5.9 g H
94.1 g O
H2O2
n = 2
∴ (HO)2
5.9 g • (1mol/1 g) = 5.9 mol H
94.1 g * (mol/16 g) = 5.9 mol O
→ H5.9O5.9 ÷ 5.9 = HO
MM = 34 g/mol
n = MW/EW
=34/17
= 2
1H + 1O
=1(1) + 1(16)
= 17 g/mol

g —> mol —> improper formula —> proper formula sequence



(EX) Molecular Formula from % Composition

¿A gasoline additive has the % composition of 71.65% Cl, 24.27% C, and 4.04% H, and a molar mass of 98.96 g/mL. What is the formula?

$Cl_xC_yH_z$

$\frac{71.15\ g\ Cl}{} \times \frac{1\ mol\ Cl}{35.45\ g\ Cl} = \frac{2.021}{2.021} = 1$ Cl

$\frac{24.27\ g\ C}{} \times \frac{1\ mol\ C}{12.01\ g\ C} = \frac{2.023}{2.021} = 1$ C

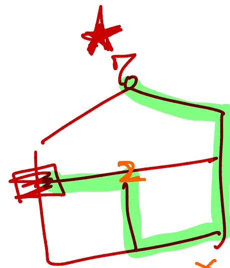
$\frac{4.04\ g\ H}{} \times \frac{1\ mol\ H}{1.008\ g\ H} = \frac{4.008}{2.021} = 2$ H

⇓

$ClCH_2$

$1(35.45) + 1(12.00) + 2(1.008)$

$\frac{49.47\ g}{mol}$ EW



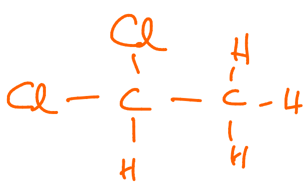

$ClCH_2$

$98.96 = n \times 49.47$

$(ClCH_2)_n$

$(ClCH_2)_2$

$Cl_2C_2H_4$



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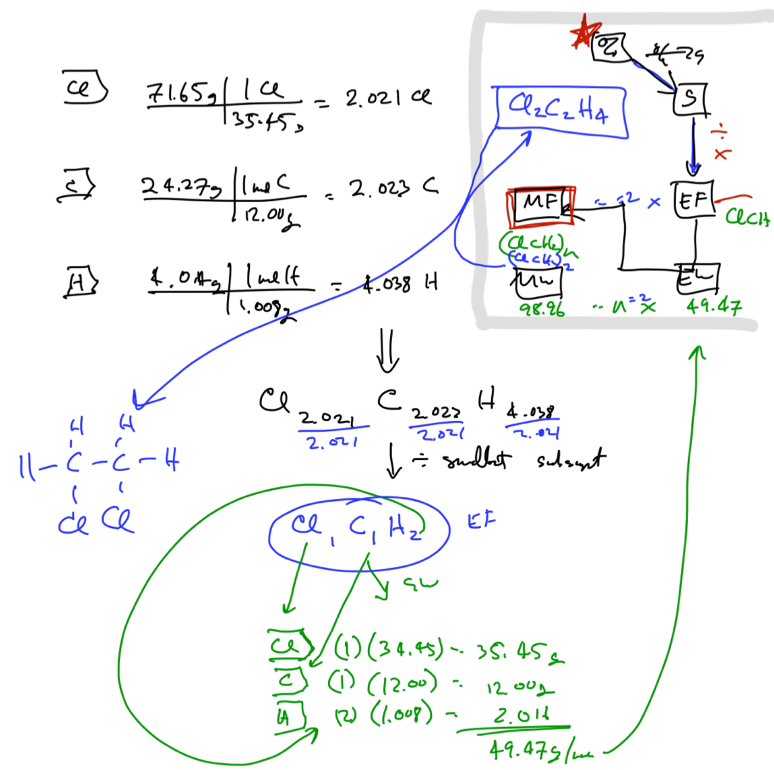


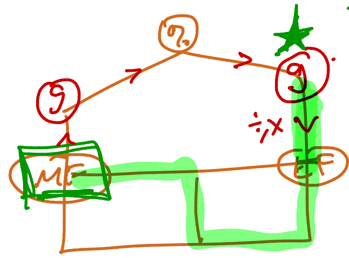
## ¿(EX) MOLECULAR COMPOSITION

What is the formula of an oxide of aluminum formed by the reaction of 4.151 g Al and 3.692 g O?

4.151 g 3.692

$$Al + O_2 \rightarrow Al_xO_y$$

mols




$\frac{4.151\text{ g Al}}{} \Big| \frac{1\text{ mol Al}}{26.98\text{ g Al}} = 0.1539\text{ mol Al}$

$\frac{3.692\text{ g O}}{} \Big| \frac{1\text{ mol O}}{16.00\text{ g O}} = 0.2308\text{ mol O}$

$Al_{\frac{0.1539}{0.1539}}O_{\frac{0.2308}{0.1539}}$

↓ (÷)

$Al_1O_{1.5}$

↓ (×)2

$Al_2O_3$

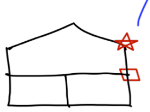
$X_1Y_{1.2}$ ↓×5 $X_5Y_6$

TOTT #4 "10% rule"

$X_{1.9}Y_{1.1}$ → $X_2Y_1$

$X_{1.05}Y_{1.1}$ ↓ ×5

Mon, Oct 28



$\frac{4.151\text{ g Al}}{} \Big| \frac{1\text{ mol Al}}{26.98\text{ g Al}} = 0.1539\text{ mol Al}$

$\frac{3.692\text{ g O}}{} \Big| \frac{1\text{ mol O}}{16.00\text{ g O}} = 0.2308\text{ mol O}$

$Al_{\frac{0.1593}{0.1593}}O_{\frac{0.2308}{0.1593}}$

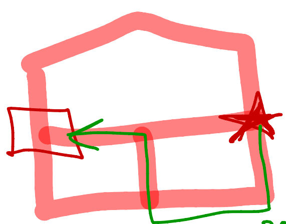
$Al_2O_3 \xleftarrow{\times 2} Al_1O_{1.5}$

## (EX) MOLECULAR COMPOSITION

¿What is the molecular formula of a compound with an empirical formula $CH_2O$ and a molecular weight of 180 g/mol?

$A_yB_yC_z$

EA | ST




$(CH_2O)_6 = C_6H_{12}O_6$

$\frac{180\,g}{mol} = n \times 30\ g/mol$

$\frac{180}{30} = \frac{30n}{30}$

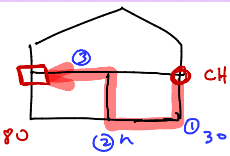
$6 = n$

$1(C) = 1(12) = 12$

$2(H) = 2(1) = 2$

$1(O) = 1(16) = 16$

$30$




① Cal. FW → ② Calc "n"

$1C = 1(12) = 12$

$2H = 2(1) = 2$

$1O = 1(16) = 16$

$CH_2O \quad 30$

$MW = n\,FW$

$\frac{MW}{FW} = n$

$\frac{180}{30} = n = 6$

↓ determ MF

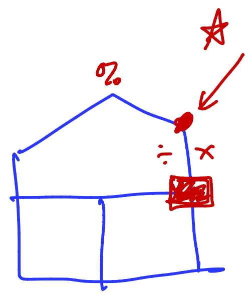
③

$MF = n(EF)$

glucose $C_6H_{12}O_6$ ← $6(CH_2O) = MF$

$C_6H_{12}O_6$

¿ A 24.54 gram sample of copper is heated in the presence of excess fluorine. A metal fluoride is formed with a mass of 31.88 g. Determine the empirical formula of the metal fluoride.     [OWL 8.8]




24.54g, Cu

7.34g, F

$Cu_xF_y$

$\underset{24.54g}{Cu} + \underset{7.34g}{F_2} \rightarrow \underset{31.88g}{CuF}$

$$\begin{array}{r} 31.88 \\ -\,24.54 \\ \hline 7.34g \end{array}$$

Cu: $\dfrac{24.54g\ Cu}{} \times \dfrac{1\ mol\ Cu}{63.6\ g\ Cu} = \dfrac{0.386\ mol\ Cu}{0.386}$

F: $\dfrac{7.34g\ F}{} \times \dfrac{1\ mol}{19.0\ g} = \dfrac{0.386\ mol\ F}{0.386}$

$Cu_1F_1$

# Sample Wt%-to-Molecular Formula Problem

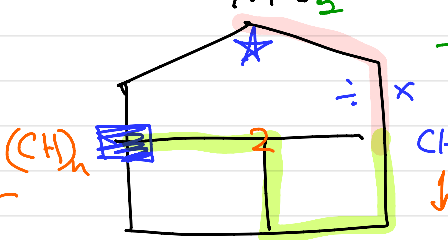
Acetylene is 92.3% C, 7.7% H, and its molar mass is 26 g/mol. What is the molecular formula?

92.3 g C
7.7 g H

$$\frac{92.3\text{ g C}}{} \left| \frac{1\text{ mol C}}{12.0\text{ g C}} \right. = \frac{7.7\text{ mol C}}{7.7}$$

$$\frac{7.7\text{ g H}}{} \left| \frac{1\text{ mol H}}{1.0\text{ g H}} \right. = \frac{7.7\text{ mol H}}{7.7}$$

$C_1H_{1.0}$




1(H) = 1(1.0)
1(C) = 1(12.0)
1 CH = 13.0 g

$$\text{mm} \rightarrow \frac{26\text{ g}}{\text{mol}} = n \times \frac{13\text{ g}}{\text{mol}}$$

$(CH)_2 = C_2H_2$

H–C≡C–H

$C_1H_{1.5}$ ×2 → $C_2H_3$

$CH_{1.25}$ ×4 → $C_4H_5$

1.8

EF?
MF?

1. MM = 100. g/mol

$65.45\%\ C \mid 12.0 \rightarrow 5.45\ mol\ C$

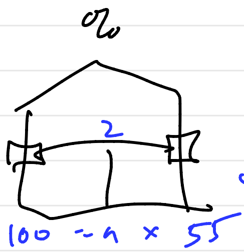
$5.45\%\ H \mid \rightarrow 5.40\ mol\ H$

$29.09\%\ O \mid 16.0 = 1.82\ mol\ O$

$C_{\frac{5.45}{1.82}} H_{\frac{5.40}{1.82}} O_{\frac{1.82}{1.82}}$

$C_{2.9} H_{2.9} O_1$

$C_3H_3O$




$C_3H_3O \rightarrow$
$3(12) = 36$
$3(1) = 3$
$1(16) = 16$
$55$

$(C_3H_3O)_n = (C_3H_3O)_2 = \boxed{C_6H_6O_2}$

Sample Problem: Turning molecular formula into equation
(Make an 'equation' in which the molecule breaks down into individual atoms)

$O_2$, mol O

3.81 moles of oxygen molecules contain how many oxygen atoms?

$1 O_2 \rightarrow 2 O$

3.81 → ?

$\text{\# atoms O} = \frac{3.81 \text{ mol } O_2}{} \left| \frac{2 \text{ mol O}}{1 \text{ mol } O_2} \right| \frac{6.02E23 \text{ at}}{1 \text{ mol O}}$ → # atoms

A 'formula' made for sulfur acid would look like this…

$H_2SO_4 \rightarrow 2H + 1S + 4O$