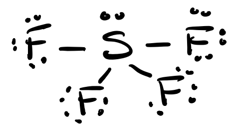
Examples from Chapter 4

problem 90)

a) SF_4



AX_4E

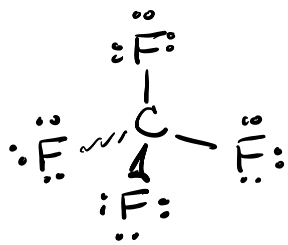
$\Delta EN = 4.0 - 3.0 = 1.0$

yes polar bond

$\Rightarrow$ molecule polar ?

yes polar ✓

b) CF_4



AX_4

$\Delta EN = |4.0 - 2.5| = 1.5$

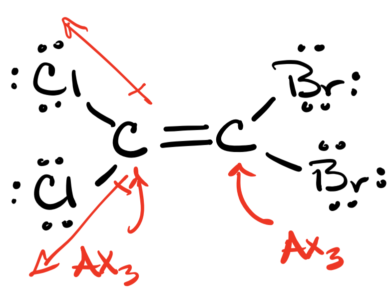
yes polar bonds

$\Longrightarrow$ molecule polar ?

AX_4 all dipoles cancel

Not polar

c) Cl_2CCBr_2



polar

C–Cl [3.0] $3.0 - 2.5 = 0.5$

C–Br [2.8] $2.8 - 2.5 = 0.3$

C–C $\Delta EN = 0$ not polar

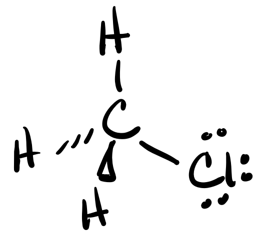
Does it contain polar bonds $\Rightarrow$ yes

not AX_4, AX_3, AX_2

$\Longrightarrow$ polar ✓

d) CH_3Cl

e) H_2CO



AX_4

C–H ΔEN $2.5-2.1=0.4$ not polar

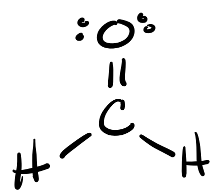
C–Cl $3.0-2.5=0.5$ polar

Does it contain polar bonds? yes ✓

Is the molecule polar

AX_4, AX_3, AX_2 where all X's same?

$\Longrightarrow$ yes polar



C–O $3.5-2.5=1$ polar

C–H $2.5-2.1=0.4$ nonpolar

AX_3

polar bonds? yes ✓

Is molecular polar?

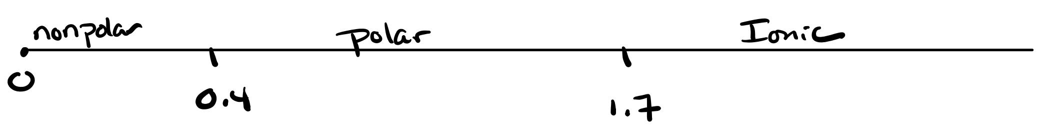
AX_4, AX_3, AX_2 | X's all same

NO $\Longrightarrow$ polar ✓

Polar vs nonpolar bond

$\Delta EN = |EN_1 - EN_2|$

EN values are in a table in chapter 4 (4.6)



$0 \leq 0.4$ $0.4 \leq 1.7$ >1.7

Finished Chapter 4 with Molecular Polarity

Skip Chapter 5 ⟹ Deeper into Covalent bonding

Chapter 6

6.1 molar mass ⇐ we covered

C_3H_6O

$$
\begin{aligned}
3 \times 12.01 &= 36.03 \\
6 \times 1.008 &= 6.048 \\
1 \times 16.00 &= 16.00 \\
\hline
& 58.078 \\
&= 58.08 \text{ g/mole}
\end{aligned}
$$

⟹ 6.2 Finding Emperical & Molecular formulas

Why?

How do you find the molecular formula for a new compound?

Emperical Formula

⇒ Smallest whole number ratios of atoms in a molecule

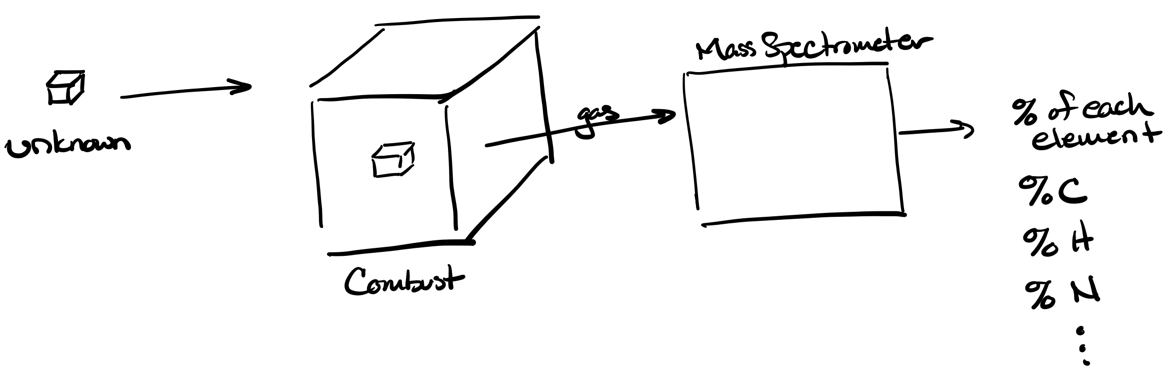
$C_6H_{12}O_6$ molecular formula

$\frac{C_6}{6}\frac{H_{12}}{6}\frac{O_6}{6} = C_1H_2O_1$ = Emperical Formula

$6(CH_2O) = C_6H_{12}O_6$

6 × Emperical = molecular By formula but also

$6 \times (30.03 g/mol) = 180.16 g/mol$ by mass



Combustion analysis
% composition

There is a way to rebuild to Emperical formula from % Composition.

Steps

① Convert % to a mass in grams — % → mass

② Convert grams to moles of each element — mass → moles

③ Find smallest whole number ratio of moles — divide by small

④ If ratios fractional, multiply by value to obtain whole numbers — mult til whole

0.25
0.5
0.75

$$2\times(C_1H_{1.5}O_1) = C_2H_3O_2$$

fraction

$$4\times(CH_{1.25}O) = C_4H_5O_4$$

⇒ This is the emperical formula

⑤ Find molar mass of emperical

⑥ Divide the molar mass of compound by molar mass of emperical

$$\frac{\overset{\text{molecular mw}}{180.16}}{\underset{\text{Emperical mw}}{30.03}} = 6$$

← # of emperical units in molecular

⑦ multiply subscript by units to obtain the molecular formula.

Combustion analysis of a Compound affords 40.00% C, 6.71% H and 53.29% Oxygen. Find the emperical Formula.

% → mass

mass → mole

divide by small

Sometimes Required → mult. til whole

	C	H	O
%	40.00%	6.71%	53.29%
g	40.00 g	6.71 g	53.29 g

100g sample

mole

$40.00\,g\,C \times \frac{1\ mole\ C}{12.01\,g\,C}$ $6.71\,g\,H \times \frac{1\ mole\ H}{1.008\,g\,H}$ $53.29\,g\,O \times \frac{1\ mole\ O}{16.00\,g\,O}$

smallest

$= 3.33055786844$ mole C $= 6.65674603175$ mol H $= 3.330625$ mole O

Divide by Small

$\frac{3.33055786844}{3.33055786844} = 1$ $\frac{6.65674603175}{3.33055786844} = 2$ $\frac{3.330625}{3.33055786844} = 1$

Emperical Formula $= C_1H_2O_1$

If the molecule in question is found to have a molar mass of 90.09 g/mole, what is the molecular formula?

Emperical Formula CH_2O part

Molar Mass of Molecular 90.09 g/mole whole

Molecular Formula ?

How many times does the part divide into the whole?

whole

part

$$\frac{90.09 \text{ g/mol}}{CH_2O} = \frac{90.09 \text{ g/mole}}{12.01 + 2(1.008) + 16.00 \text{ g/mole}} = \frac{90.09 \text{ g/mole}}{30.03 \text{ g/mol}}$$

$$= \underline{\underline{3}}$$

3 x Emperical mass = molecular mass

3 x Eperical formula = molecular formula

$$3(CH_2O) = \boxed{C_3H_6O_3}$$

Molecular Formula

A Compound with a molar mass of 240. g/mole is found to have a composition of 75.95% C, 17.72% N and 6.33% H. What is the molecular formula?

	C	N	H
%	75.95%	17.72%	6.33%
mass	75.95 g	17.72 g	6.33 g
moles	$75.95\,g \times \frac{1\,mole\,C}{12.01\,g\,C}$	$17.72 \times \frac{1\,mole}{14.01\,g\,N}$	$6.33\,g \times \frac{1\,mole}{1.008\,g\,H}$
	= 6.32389675271	= 1.26481684939	= 6.27976190476
Divide by Small	$\frac{6.32389675271}{1.26481684939}$	$\frac{1.26481684939}{1.26481684939}$	$\frac{6.27976190476}{1.26481684939}$
	5	1	5

Empirical Formula C_5NH_5 =

$5 \times 12.01 = 60.05$
$1 \times 14.01 = 14.01$
$5 \times 1.008 = 5.040$
79.100

79.10 g/mole

$$\frac{\text{Part}}{\text{whole}} = \frac{\text{molecular}}{\text{Emperical}} = \frac{240.\ g/mole}{79.10\ g/mole} = 3.034134$$

= whole number

1, 2, 3, 4 ...

3 x Emperical = molecular

$$3(C_5H_5N) = \boxed{C_{15}H_{15}N_3}$$ ✓

Molecular Formula

or

$C_{15}N_3H_{15}$ okay

Check

15 x 12.01 =

15 x 1.008 =

3 x 14.01 = +

237.3 g/mole Close to 240 g/mole

halogen

Metal C H O N X

order used by Convention

% Composition

$$\frac{\text{Part}}{\text{whole}} \times 100$$

Ex

Calculate to % Composition of nitrogen in ammonia (NH_3)

$$\% = \frac{\text{Part}}{\text{whole}} \times 100$$

$$= \frac{N}{NH_3} \times 100$$

$$= \frac{14.01\ \text{g/mole}}{14.01\ \text{g/mole} + 3(1.008\ \text{g/mol})} \times 100 = \frac{\overset{4}{14.01}\ \text{g/mol}}{\underset{4}{17.034}\ \text{g/mole}} \times 100$$

$$= 82.247\ 270\ 165\ \%$$

$$= \boxed{82.25\%\ N \text{ in } NH_3 \text{ by mass}}$$

Calculate the % of hydrogen in ammonia.

NH_3 ammonia

$$\% = \frac{\text{Part}}{\text{whole}} \times 100 = \frac{3H}{NH_3} \times 100$$

$$= \frac{3(1.008\ g/mol)}{14.01\ g/mol + 3(1.008\ g/mol)} \times 100 = \frac{3.024\ g/mole}{17.034\ g/mole} \times 100$$

4

4

$= 17.752729$

$$\boxed{= 17.75\ \%\ H \text{ by mass in } NH_3}$$

What is the % of Nitrate in Iron(III) nitrate by mass?

Fe^{3+}	NO_3^-
	NO_3^-
	NO_3^-
$3+$	$3-$

$Fe(NO_3)_3$

$14.01 + 3(16.00) = 62.01\ g/mol$

$$\% = \frac{3\ NO_3^-}{Fe(NO_3)_3} \times 100$$

$55.84 + 3(14.01) + 9(16.00) = 241.87\ g/mole$

$$\% = \frac{3 \times 62.01\ g/mole}{241.87\ g/mole} \times 100 = 76.913217\ \%$$

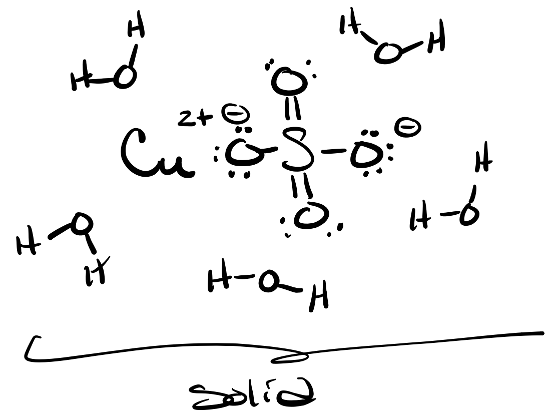
$$\boxed{Fe(NO_3)_3 \text{ is } 76.91\%\ NO_3^- \text{ by mass}}$$

What is the % of water in Copper (II) Sulfate pentahydrate ?

Cu^{2+}	SO_4^{2-}
2+	2-

hydrate

$CuSO_4 \cdot 5H_2O$



$$\% = \frac{\text{Part}}{\text{whole}} \times 100$$

$$\% = \frac{5H_2O}{CuSO_4 \cdot 5H_2O} \times 100$$

$$\frac{5(2 \times 1.008 + 16.00)}{63.55 + 32.07 + 4(16.00) + 5(2 \times 1.008 + 16.00)} \times 100 =$$

$$\frac{5 \cdot 18.016 \text{ g/mole}}{159.62 \text{ g/mole} + 5 \cdot 18.016 \text{ g/mole}} =$$

$$\frac{90.08 \text{ g/mol}}{249.70 \text{ g/mol}} \times 100 = 36.075290 \% \ H_2O$$

$$\boxed{= 36.08 \% \ H_2O \text{ by mass}}$$

6.3 Concentration tomorrow