Chemistry (Handout)   Form 3

Topic: Empirical formula and Molecular formula
Definition:

The Empirical formula of a compound shows the simplest ratio of the numbers of
atoms of the different atoms in it.
The Molecular formula of a compound above the actual numbers of atoms of the
different elements in one mole of it.

Examples of Empirical formula and Molecular formula

Substance   Molecular formula   Empirical formula
Hydrogen Chloride   HCl   HCl
Ethane C_2H_6 CH_3
Glucose $C_6H_{12}O_6$ CH_2O

Note: in some cases EF is the same as MF see HCl above

Determining EF and MF given % Composition by mass
A compound consist of 80% Carbon and 20% Hydrogen by mass and its relative
molecular mass is 30. Find its Empirical formula and hence its molecular formula.
R.M.M: C=12; H=1

Elements	C	H
%Composition	80	20
divide by atomic masses	80/12	20/1
	6.67	20
divide by smallest no.	6.67/6.67	20/6.67
	1	2.99
smallest ratio	1	3

EF   is CH_3

To find the MF use n multiplied by EF= MF (RMM)   (n x E.F = RMM)
                    n(12+3)   = 30
                    15n   = 30   hence n=2

Molecular formula is 2 multiplied by CH_3 i.e. C_2H_6

A guide to rounding up or down in these type of calculations.

REMEMBER rounding off occurs **only after** dividing by the smallest number.
If the decimal ends in 0.1 or 0.2................ ROUND DOWN (safe decimals)

If the decimals ends in 0.3, 0.4, 0.5, 0.6 or 0.7…..MULTIPLY current numbers by 2,3,4,5 in turn UNTIL "safe decimal" achieved.

If the decimal ends in 0.8 or 0.9 …………………ROUND UP (safe decimals)

Ex consider	X	Y
Divide by smallest no	2.34/2.34	5.38/2.34
	1	2.29…… not in the safe zone
x by 2	2	4.58…… not in the safe zone
x by 3	3	6.87…….in the safe zone so round up
whole number ratio	3	7

E.F   is X_3Y_7

Empirical (Simplest) Formulae (some more examples!)

$C_6H_{12}O_6$ $= C_1 H_2 O_1$

$H_2 O$ $= HO$

$C_4 H_{12}$ $= CH_3$

$C_5 H_{10}$ $= CH_2$

Example #1

A certain compound contains 40% by mass carbon, 6.7% hydrogen and 53.5% oxygen. Find the simplest (empirical) formula.

	C	H	O
% composition	40	6.7	53.5
Divide by relative atomic mass (RAM)	$\frac{40}{12}$	$\frac{6.7}{1}$	$\frac{53.5}{16}$
	=3.33	= 6.7	3.34
Divide each by smallest #	$\frac{3.33}{3.33}$	$\frac{6.7}{3.33}$	$\frac{3.34}{3.33}$
	1	2.01	1
		↑	
		safe zone (round down)	

Empirical formula $C H_2 O$

<u>Example #2</u>
   To find the MOLECULAR FORMULA

n x empirical formula = molecula formula

where n is an integer e.g. 1, 2, 3, 4 ....

Find (i) empirical formula (ii) molecular formula for a compound which has an RMM of 32 and contains 87.5% nitrogen and 12.5% hydrogen.

	N	**H**
% composition	87.5	12.5
Divide each by RAM	$\dfrac{87.5}{14}$ = 6.25	$\dfrac{12.5}{1}$ = 12.50
Divide each by smaller #	$\dfrac{6.25}{6.25}$	$\dfrac{12.50}{6.25}$
	1	2

Empirical formula = NH_2

n x E.F = M.F

RMM of NH2 = (1x14) + (1x2) = 16
  RMM of M.F = 32
  n x 16 = 32
  n = $\dfrac{32}{16}$ = 2

Molecular formulae is $(NH_2)_2$ = N_2H_4.

Special cases

.5

multiply
throughout
  by 2

.33   .66
.34   .67

   multiply
throughout by 3

.25

multiply
throughout by 4

Example #3
    A certain compound contains 82.8 % carbon and the rest is made up of hydrogen. If the RMM is 58, find its (i) empirical formula and (ii) its molecular formula.

(i)   % H = 100% - 82.5% C = 17.2%

	C	H
% composition	82.8	17.2
Divide by their AR	$\dfrac{82.8}{12}$	$\dfrac{17.2}{1}$
	= 6.90	= 17.2
Divide by smallest	$\dfrac{6.90}{6.90}$	$\dfrac{17.2}{6.90}$
	= 1	= 2.49← (unsafe decimal)
	= 2	= 4.98←safe zone (round up)

2.49⌐ special case x 2
4.98⌐ throughout

    Empirical formula   = C_2H_5

(ii)   n x E.F = M.F
       RMM of C_2H_5 = (2x12) + (5x1) = 29

    n x 29 = 58
     n = $\dfrac{58}{29}$
      = 2

Molecular formula is $(C_2H_5)_2$ = C_4H_{10} Ans

Empirical (simplest) Formula
Worksheet
3rd form

1. Calculate the empirical formulae for the following compounds which contains
   - (i)   52.2% carbon, 13.0% hydrogen and 34.8% oxygen
   - (ii)   92.8% lead, 7.2% oxygen
   - (iii)   39.3% sodium, 60.7% chlorine
   - (iv)   40% calcium, 12% carbon, 48% oxygen
   - (v)   43.2 sodium, 11.3% carbon, 45.3% oxygen

2. Calculate the empirical formulae for the compounds with the following % compositions:
   - (i)   72.4% iron, 27.6% oxygen
   - (ii)   56.3% oxygen and the rest is made up of phosphorus
   - (iii)   28% iron, 24% sulphur and 48% oxygen

3. A certain hydro-carbon contains 83.7% carbon and 16.3% hydrogen. If its relative molecular mass (RMM) is 86, find (i) its empirical formula (ii) its molecular formula.

4. Calculate (i) The Empirical Formula (ii) Molecular Formula in each of the following cases:
   - (i)   C= 93.3%   H= 7.7% ; relative molecular mass (RMM) = 78
   - (ii)   N= 87.5%   H=12.5%; R.M.M=32
   - (iii)   C= 40%   H=6.7%   O=53.3%; RMM=180
   - (iv)   P= 43.7%   O=56.3%; RMM=284
   - (v)   C= 81.8%   H=18.2% ; RMM=44
   - (vi)   Na=32.4%   S=22.6% O= 45.0% ; RMM = 142