SOME IMPORTANT DEFINITIONS

Ex. Find the % H_2O in gypsum salt $CaSO_4 \cdot 2H_2O$

$40+32+64+2\times18 =$

$136+36 = 172$

$$\%\, H_2O = \frac{18\times2}{172}\times100$$

Ex. If epsum salt ($MgSO_4 \cdot x H_2O$) has $\%H_2O$ is 60% by mass find no of hydrated water.

$$60\% = \frac{18\cdot x}{120+18x}\times100 \Rightarrow 30x = 120+18x$$

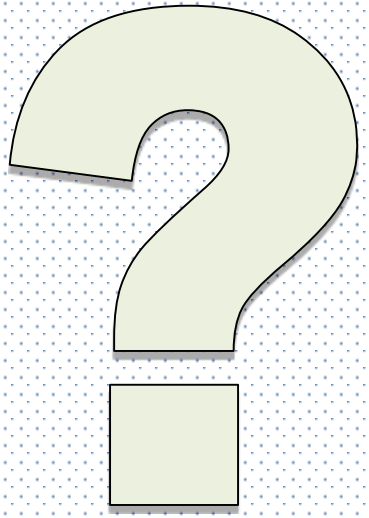
$$12x = 120$$

$$x = 10$$

ILLUSTRATIONS

Question : Calculate number of atoms present in 1 drop of water having volume 3.6 ml. density 1 g/ml

Solution :



$$\text{Density} = \frac{\text{mass}}{\text{volume}}$$

$$\text{Mass} = \text{volume} \times \text{density} = 3.6\ \text{g}$$

3.6 ml × 1 g/ml

$$n_{H_2O} = \frac{3.6}{18} = 0.2$$

$$n_{atom} = 0.2 \times 3 = 0.6$$

$$\text{No. of atoms} = 0.6 \times 6 \times 10^{23} = 3.6 \times 10^{23}$$

No of atom = moles of H_2O × N_A × atomicity

= 0.2 × N_A × 3

= 0.6 N_A Ans.

Percentage Composition:

1 mole CH_4

$$\text{Mass \% of C} = \frac{12}{16} \times 100 = \frac{1 \times 12}{16} \times 100$$

$$\text{Mass \% of H} = \frac{4}{16} \times 100 = \frac{4 \times 1}{16} \times 100$$

Mass % of element in compound

$$= \left(\frac{\text{Atomicity} \times \text{Atomic weight}}{\text{Molecular wt.}} \times 100 \right)$$

MOLE

If minimum molecular mass is asked, then assuming at least 1 atom per molecule of the element.

Mass % of element in compound

$$= \frac{1 \times \text{At. wt. of element}}{\text{Min. molecule wt.}} \times 100$$

minimum atom = 1 + Atomicity = 1

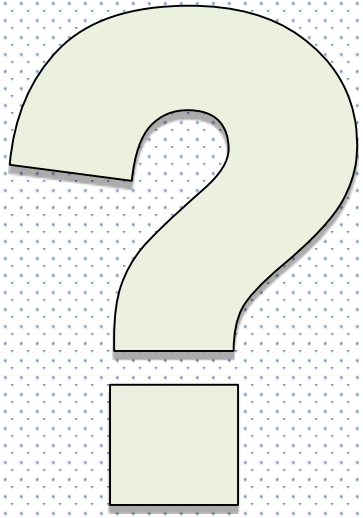
% Comp.

ILLUSTRATIONS

Question : Determine the mass % of each element in $Fe_2(SO_4)_3$.

$56 \times 2 + 96 \times 3 = 0$

$112 + 288 = 400$



$\% Fe = \frac{56 \times 2}{400} \times 100$

$\% Fe = 28\%$

$\% S = \frac{32 \times 3}{400} \times 100 = 24\%$

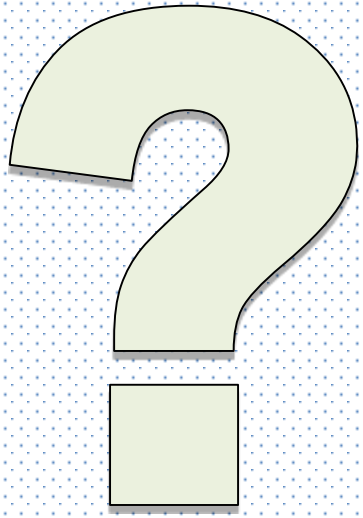
$\% O = 100 - 28 - 24$

$= 48\%$

ILLUSTRATIONS

Question : Determine the mass % of each element in $Fe_2(SO_4)_3$.

Solution :



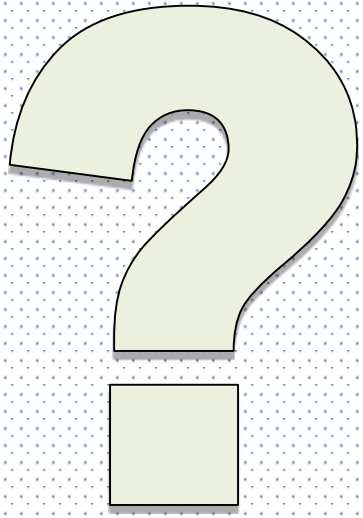
$$\text{Mass \% of Fe} = \frac{2 \times 56}{400} \times 100 = 28\%$$

$$\text{Mass \% of S} = \frac{3 \times 32}{400} \times 100 = 24\%$$

$$\text{Mass \% of O} = \frac{12 \times 16}{400} \times 100 = 48\%$$

ILLUSTRATIONS

Question : A metal M forms a metal carbonate M_2CO_3, if the carbonate contains 48% oxygen by mass, then determine the atomic wt. of metal.



$(2M+60)$

$$\% \ O = \frac{16 \times 3}{2M+60} \times 100 = 48$$

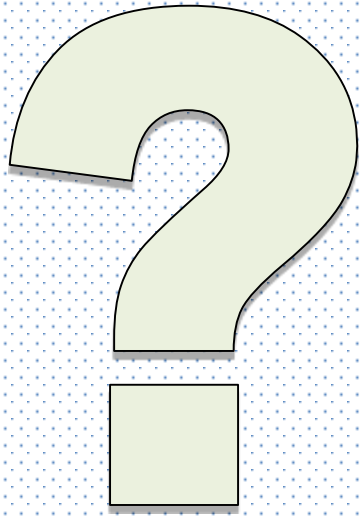
$$2M + 60 = 100$$

$$2M = 40$$

$$M = 20 \ g/mol$$

ILLUSTRATIONS

Question : A metal M forms a metal carbonate M_2CO_3, if the carbonate contains 48% oxygen by mass, then determine the atomic wt. of metal.



Solution : % weight of element = $\frac{\text{Atomicity} \times \text{Atomic weight}}{\text{Molecular weight}} \times 100$

$$48 = \frac{3 \times 16}{Mw} \times 100$$

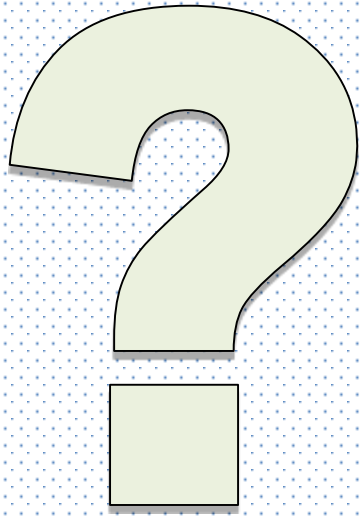
$$Mw = 100$$

$$2M + 12 + 48 = 100$$

$$M = 20$$

ILLUSTRATIONS

Question : Calculate the minimum molecular wt. of a compound that contains 28% N by mass.



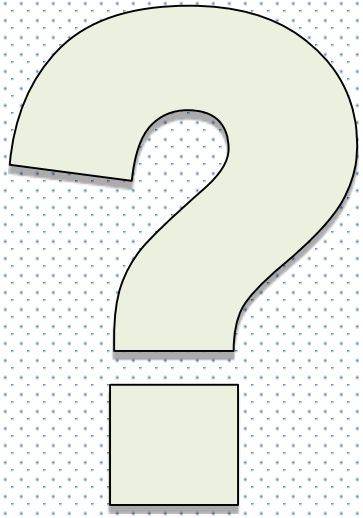
$$\%\,N = \frac{\text{Atomic mass} \times \text{Atomicity}}{\text{Molecular mass}} \times 100$$

$$\frac{2}{28} = \frac{14 \times 1}{\text{Min molecular mass}} \times 100$$

Minimum molecular mass = 50 g/mol

ILLUSTRATIONS

Question : Calculate the minimum molecular wt. of a compound that contains 28% N by mass.



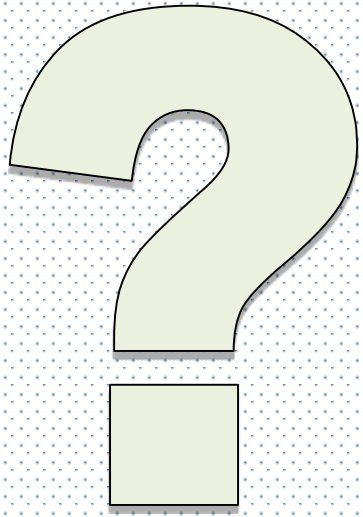
Solution : % weight of element = $\frac{1 \times \text{Atomic weight}}{\text{Minimum molecular weight}} \times 100$

$$28 = \frac{14 \times 100}{\text{Minimum Mw}}$$

Minimum Mw = 50

ILLUSTRATIONS

Question : In blood sample, Haemoglobin contains 0.56% by mass of iron. Then calculate minimum molecular mass of Haemoglobin. If atomic mass of Fe is 56 a.m.u.



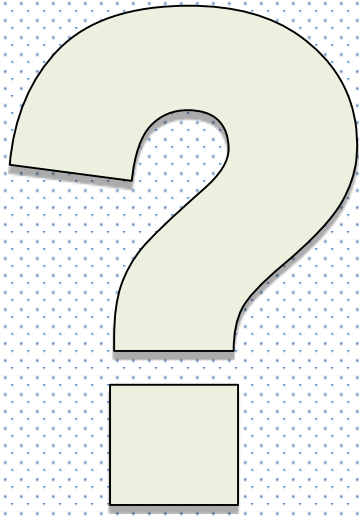
$$\%\ Fe = \frac{\text{Atomic mass} \times \text{Atomicity of Fe}}{\text{Molecular mass}} \times 100$$

$$0.56 = \frac{56 \times 1}{x} \times 100$$

$$x = 10000 \text{ amu or g/mol.}$$

ILLUSTRATIONS

Question : In blood sample, Haemoglobin contains 0.56% by mass of iron. Then calculate minimum molecular mass of Haemoglobin. If atomic mass of Fe is 56 a.m.u.



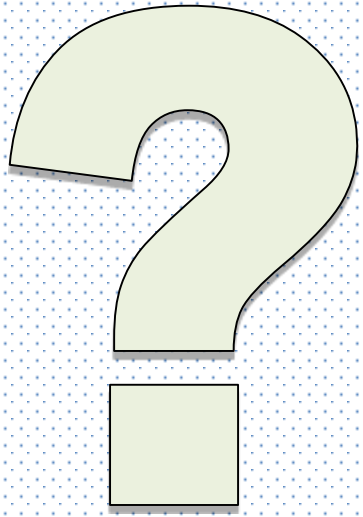
Solution : % weight of element = $\frac{1 \times \text{Atomic weight}}{\text{Minimum molecular weight}} \times 100$

$$0.56 = \frac{1 \times 56}{\text{Minimum Mw}} \times 100$$

Minimum Mw = 10^4

ILLUSTRATIONS

Question : How many number of iron atoms will be present in Haemoglobin if its molecular mass is 80000 in which 0.28% iron atoms are present. Atomic mass of iron is 56.



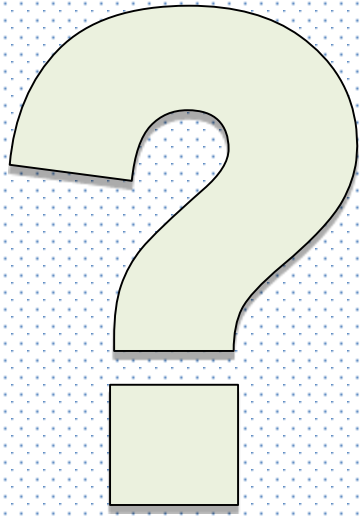
$$\% \text{ Fe} = \frac{\text{Atomic mass of Fe} \times \text{atomicity}}{\text{Molecular mass}} \times 100$$

$$0.28 = \frac{2}{56} \times x \times 100$$

$$x = 4$$

ILLUSTRATIONS

Question : How many number of iron atoms will be present in Haemoglobin if its molecular mass is 80000 in which 0.28% iron atoms are present. Atomic mass of iron is 56.



Solution : % weight of element = $\frac{\text{Atomicity} \times \text{Atomic weight}}{\text{Molecular weight}} \times 100$

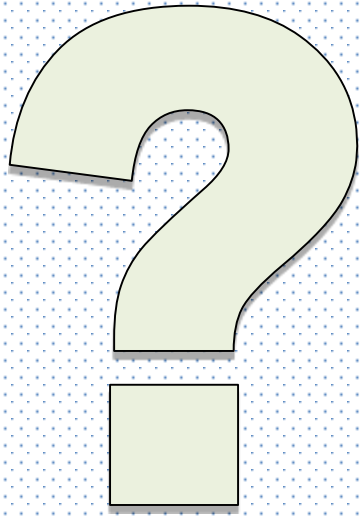
$$0.28 = \frac{x \times 56}{80000} \times 100$$

$$x = \frac{28 \times 8}{56}$$

$$x = 4$$

ILLUSTRATIONS

Question : Calculate the molecular weight of a compound that contains 3.5% S by mass and each molecule contains 4 atoms of S in it.



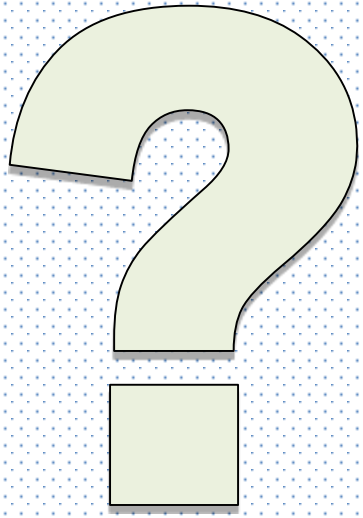
$$\% S = \frac{\text{Atomic mass of S} \times \text{atomicity}}{\text{Molecular mass}} \times 100$$

$$3.5 = \frac{32 \times 4}{\text{Molecular mass}} \times 100$$

$$\text{Molecular mass} = \frac{12800}{3.5} = 3657.14$$

ILLUSTRATIONS

Question : Calculate the molecular weight of a compound that contains 3.5% S by mass and each molecule of contains 4 atoms of S in it.



Solution : % weight of element = $\frac{\text{Atomicity} \times \text{Atomic weight}}{\text{Molecular weight}} \times 100$

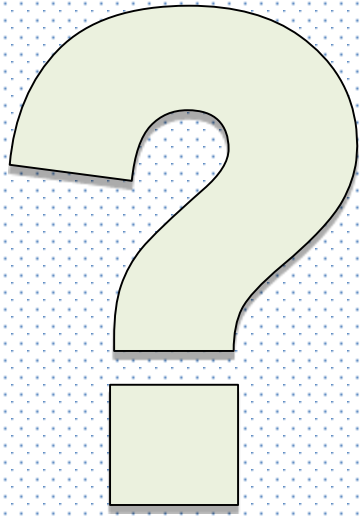
$$3.5 = \frac{4 \times 32}{Mw} \times 100$$

$$Mw = \frac{4 \times 32}{3.5} \times 100$$

$$Mw = 3650$$

ILLUSTRATIONS

Question : The molecular wt. of compound is 500 a.m.u., if the compound contains 50.4% by mass of C, then determine the no. of carbon atoms in each molecule of compound.



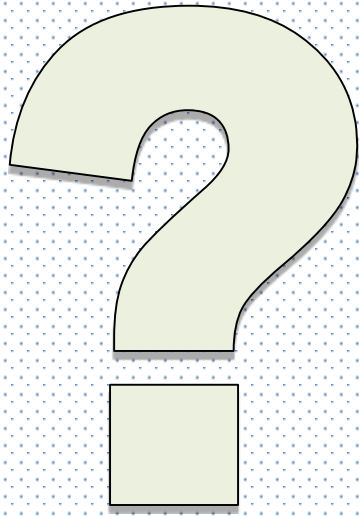
$$\% \text{ of } C = \frac{\text{Atomic mass} \times \text{Atomicity}}{\text{Molecular mass}} \times 100$$

$$50.4 = \frac{12 \times x}{500} \times 100$$

$$x = 21 \text{ atoms of } C$$

ILLUSTRATIONS

Question : The molecules wt. of compound is 500 a.m.u., if the compound contains 50.4% by mass, then determine the no. of carbon atoms in each molecule of compound.



Solution : % weight of element = $\frac{\text{Atomicity} \times \text{Atomic weight}}{\text{Molecular weight}} \times 100$

$$50.4 = \frac{x \times 12}{500} \times 100$$

$$x = \frac{50.4 \times 5}{12}$$

$$= 4.2 \times 5$$

$$= 21$$

SOME IMPORTANT DEFINITIONS

Ex. Find the change in % of N if from NH_3 all hydrogen are replaced deuterium ND_3

$$\%\ N \text{ in } NH_3 = \frac{14}{17} \times 100 = 82.35\%$$

$$\%\ N \text{ in } ND_3 = \frac{14}{20} \times 100 = 70\%$$

$$\text{change } \%\ N = 12.35\%$$

MOLE

Chemical Formula of a Compound

Molecular Formula :

Shows actual number of all the atoms present in a molecule.

glucose $C_6H_{12}O_6$ 6 : 12 : 6

Empirical Formula : 1 : 2 : 1

Shows the simplest ratio of all the atoms in a molecule.

CH_2O

Mole Concept

MOLE

Molecular Formula	Empirical Formula
$C_6H_{12}O_6$	CH_2O
C_2H_6	CH_3
NH_3	NH_3
N_2O_4	NO_2

Example :

MF	**EF**
$C_6H_6 \div 6$	CH
Mw = 78	EFw = 13

Mole Concept

SOME IMPORTANT DEFINITIONS

	MF	Molecular mass	EF	Empirical formula mass
Benzene	C_6H_6	78	CH	13
Ethyne	C_2H_2	26	CH	13
glucose	$C_6H_{12}O_6$	180	CH_2O	30
Acetic acid	CH_3COOH $C_2H_4O_2$	60	CH_2O	30

Compound having same empirical formula contains same composition of each element.

SOME IMPORTANT DEFINITIONS

$MF = n[EF]$

Acc. to mass conservation

Molecular mass = n Empirical formula mass

$$n = \frac{\text{molecular mass}}{\text{Empirical formula mass}}$$

Ex. A compound has empirical formula CH_2 and it Molecular mass is 56 what will be molecular formula of compound.

Empirical formula mass = 12+2 = 14

SOME IMPORTANT DEFINITIONS

$$n = \frac{56}{14} = 4$$

$$MF = n\,[EF]$$

$$MF = 4\,[CH_2] = C_4H_8$$

Ex. A hydrocarbon Contains 25% hydrogen find empirical formula of hydrocarbon.

Element	mass	moles of atom	Simplest Ratio (SR)
H	25g	$\frac{25}{1} = 25$	$\frac{25}{6.25} = 4$
C	75g	$\frac{75}{12} = 6.25$	$\frac{6.25}{6.25} = 1$

CH_4

SOME IMPORTANT DEFINITIONS

Ex. If a hydrocarbon contains 33.33% Carbon by mole find

(1) Empirical formula

(2) Minimum molecular mass greater than 50 Less than 100.

Element	mole	SR
C	33.33	1
H	66.67	2

Ans = C_4H_8

Empirical formula CH_2

MF = n(CH_2)

M mass = n(14)

n=1 → 14

n=2 → 28 ×

n=3 → 42

n=4 → 56 ✓

n=5 → 70

SOME IMPORTANT DEFINITIONS

Ex. A metallic oxide contains 40% oxygen if atomic mass of metal is 24 find empirical formula.

E	mass	mole	SR
M	60	$\frac{60}{24} = 2.5$	1
O	40	$\frac{40}{16} = 2.5$	1

Ans MO

SOME IMPORTANT DEFINITIONS

Ex. A metal oxide containing 40% oxygen has empirical formula MO_2. if % of oxygen increases to 50% find new empirical formula.

1st oxide

E	mass	mole	SR
M	60	$60/M$	1
O	40	$\frac{40}{16}$	2

$$\frac{\frac{60}{M}}{\frac{40}{16}} = \frac{1}{2} \qquad M = 48$$

2nd oxide

E	mass	mole	SR
M	50	$50/48$	
O	50	$50/16$	

$$\frac{\frac{50}{48}}{50/16} = \frac{16 \times 50}{48 \times 50} = \frac{1}{3}$$

MO_3

SOME IMPORTANT DEFINITIONS

Ex. Two element x and y form compound if equal mass of x and y are present and their atomic masses are 20, 30 respectively find empirical formula.

E	mass	mole	SR
x	60g	$60/20 = 3$	3
y	60g	$60/30 = 2$	2

X_3Y_2

SOME IMPORTANT DEFINITIONS

Ex. Compound of element x and y has 10 g of x and 90 gm of y what will be empirical formula is Atomic mass of x = 20 and y = 40

E	mass	mole	SR
x	10	$10/20 = 0.5$	1
y	90	$\frac{90}{40} = 2.25$	4.5

$\times 2$

$= 2$

$= 9$

1.1 ≃ 1
1.3 ≃ 1
1.9 ≃ 2
1.5 × 2

X_2Y_9

SOME IMPORTANT DEFINITIONS

Hw Question :-

1) 9g of a compound contains 48 % Carbon and oxygen each remaining is hydrogen Find

   i) Empirical formula.

   (ii) if compound is distintegrated into its element 22.4 L of hydrogen is produced find molecular formula.

SOME IMPORTANT DEFINITIONS

② If a given sample of compound contains 9.81 g zinc, 1.8×10^{23} atom of chromium and 0.06 gram atom of oxygen find empirical formula.

SOME IMPORTANT DEFINITIONS

③ A gasseous compound is composed of 85.7% Carbon and rest is hydrogen. If the density of gas at 1 atm, 300K is 2.28 g/L find molecular formula.

SOME IMPORTANT DEFINITIONS

④ If volume of 0.078 gram hydrocarbon is 22.4 ml at 1 atm 273 K if its empirical formula is CH find molecular formula.

SOME IMPORTANT DEFINITIONS

- A gaseous hydrocarbon when burnt gave 0.72g H_2O and 3.08 g CO_2 find empirical formula of compound.

$$n = \frac{78}{13} = \frac{MFw}{EFw} = 6$$

$$\boxed{MF = (EF)_n}$$

$$\boxed{n = \frac{MFw}{EFw}}$$

Determination of Empirical Formula:

Determine the simplest ratio of moles or atoms of the constituting elements.

MOLE

Example:

A compound contains 20% C, 6.67% H, 26.67% O and rest is N by mass. Find its empirical formula and molecular formula if its molecular formula if its molecular mass is 60.

Solution:

Element	Mass	Moles
C	20	20 / 12 = 1.66
O	26.67	2.67 / 16 = 1.66
N	46.66	46.66 / 14 = 3.33
H	6.67	6.67 / 1 = 6.67

MOLE

Simplest Molar Ratio :

C : O : N : H = 1.66 : 1.66 : 3.33 : 6.67

= 1.66/1.66 : 1.66/1.66 : 3.33/1.66 : 6.67/1.66

= 1 : 1 : 2 : 4

So Empirical Formula = CON_2H_4

Now, $EF_w = 60$

$$n = \frac{MFw}{EFw} = 1$$

$MF_w = 60$

$MF = (CON_2H_4)_1$

MOLE

Example:

Determine Empirical Formula for compound with following percentage compositions.

15.8% carbon and 84.2% Sulphur

Solution:

	C	:	S	
Mass	15.8	:	84.2	
Mole	15.8/12	:	84.2/32	
	526		10.52	EF = CS_2
	1	:	2	

MOLE

Example:

Determine Empirical Formula for compound with following percentage compositions.
40.0% Carbon, 6.7% H and 53.3 % O

Solution:

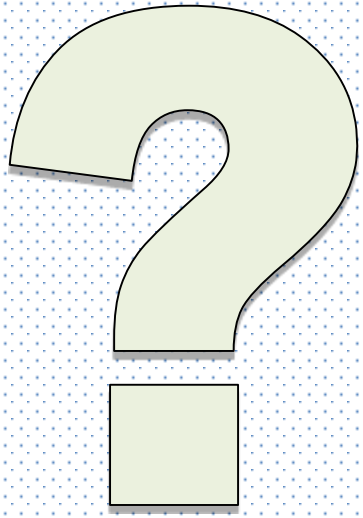
	C	H	O
Mass	40	6.7	53.3
Mol	40/12	6.7/1	53.3/16
	3.33	6.7	3.33
	1	2	1

EF = CH_2O

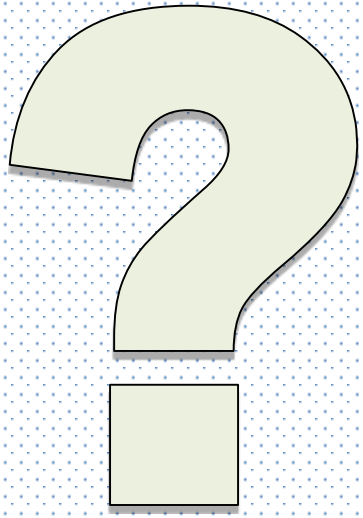
ILLUSTRATIONS

Question : Determine the empirical formula of a compound that contains H, C, O and N in the ratio of 1 : 3 : 4 : 7 by mass respectively.

Solution :



ILLUSTRATIONS



Question : Determine the empirical formula of a compound that contains H, C, O and N in the ratio of 1 : 3 : 4 : 7 by mass respectively.

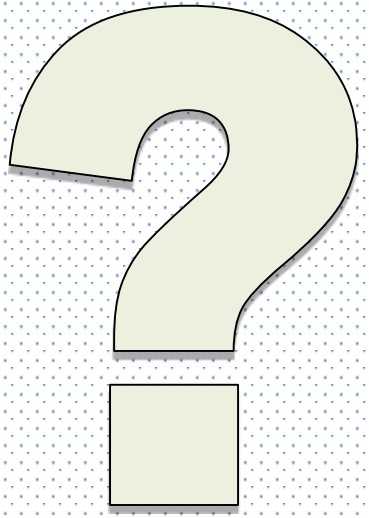
Solution :

	H		C		O		N
Mass ratio	1	:	3	:	4	:	7
Mole ratio	$\frac{1}{1}$	:	$\frac{3}{12}$	:	$\frac{4}{16}$	:	$\frac{7}{14}$
Mole ratio	4	:	1	:	1	:	2

Empirical Formula $\Rightarrow H_4CON_2$

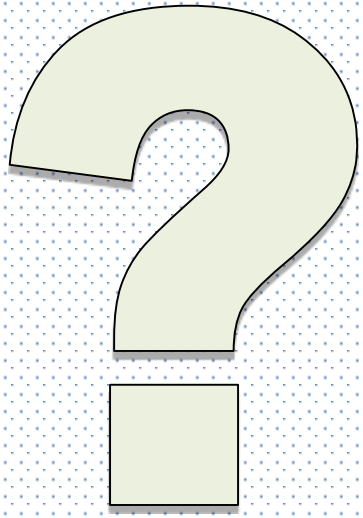
ILLUSTRATIONS

Question : Determine the empirical formula of a compound that contains 60% C, 32% O and rest H by mass.



ILLUSTRATIONS

Question : Determine the empirical formula of a compound that contains 60% C, 32% O and rest H by mass.



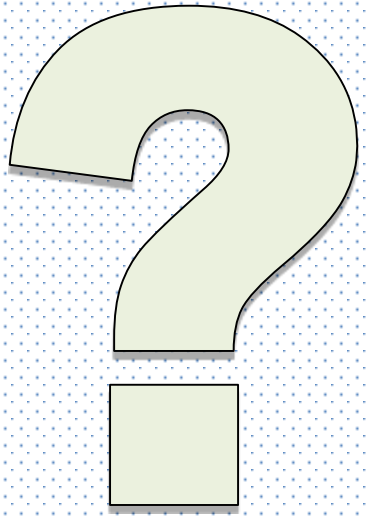
Solution :

	C		O		H
Mass ratio	60	:	32	:	8
Mole ratio	$\frac{60}{12}$	:	$\frac{32}{16}$	:	$\frac{8}{1}$
Mole ratio	5	:	2	:	8

Empirical Formula $\Rightarrow C_5O_2H_8$

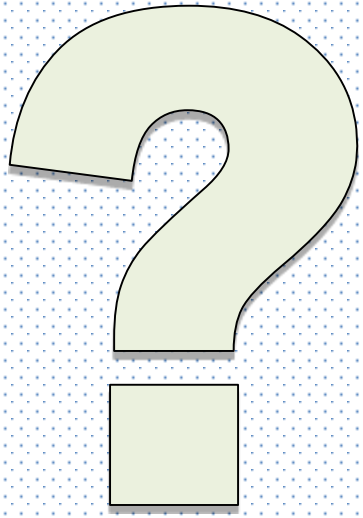
ILLUSTRATIONS

Question : Determine the empirical formula of a compound that contains 1.5×10^{21} atoms of P and 37.5×10^{20} atoms of O.



ILLUSTRATIONS

Question : Determine the empirical formula of a compound that contains 1.5×10^{21} atoms of P and 37.5×10^{20} atoms of O.



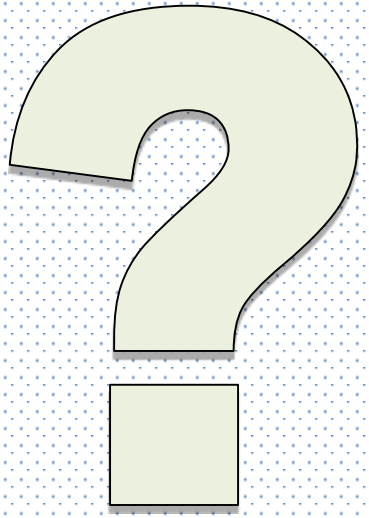
Solution :

	P		O
Mole ratio	$\frac{1.5\times10^{21}}{6\times10^{23}}$	:	$\frac{37.5\times10^{20}}{6\times10^{23}}$
Mole ratio	2	:	5

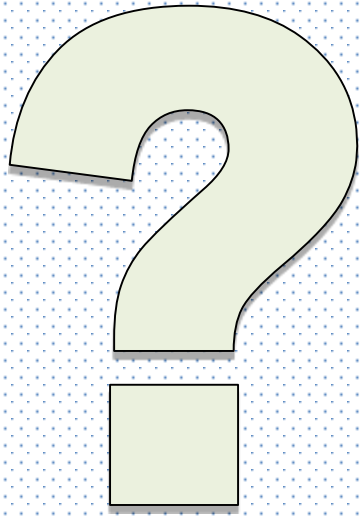
Empirical Formula $\Rightarrow P_2O_5$

ILLUSTRATIONS

Question : An organic compound contains C, H and N. If the % of C is 6 times of the % of H and the sum of % of C and H is found to be 1.5 times of the % of N, then determine the empirical formula of the compound.



ILLUSTRATIONS



Question : An organic compound contains C, H and N. If the % of C is 6 times of the % of H and the sum of % of C and H is found to be 1.5 times of the % of N, then determine the empirical formula of the compound.

Solution : Let mass % of H = x, Mass % of C = $6x$

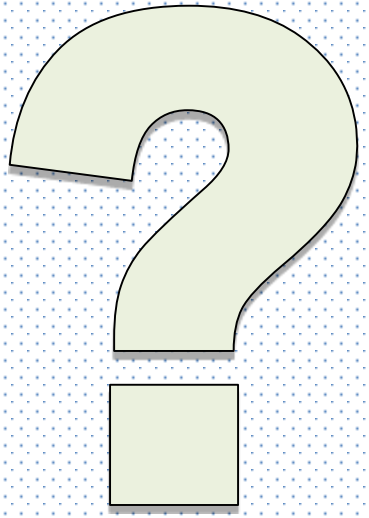
$7x$ = 1.5 (mass % o N), Mass % of N = $\frac{7x}{1.5}$

	C		H		N
Mole ratio	$\frac{6x}{12}$	:	$\frac{x}{1}$	:	$\frac{7x}{1.5\times14}$
Mole ratio	3	:	6	:	2

Empirical Formula $\Rightarrow C_3H_6N_2$

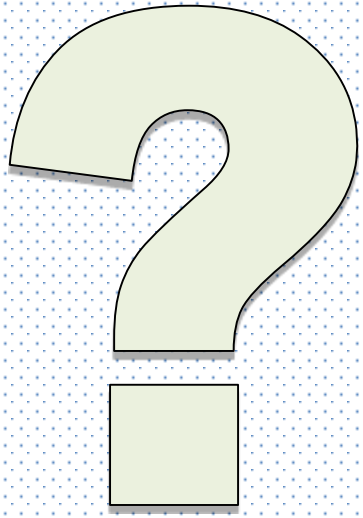
ILLUSTRATIONS

Question : Determine the empirical formula of a compound that contains 38.8% C, 16% H and rest is N by mass.



ILLUSTRATIONS

Question : Determine the empirical formula of a compound that contains 38.8% C, 16% H and rest is N by mass.

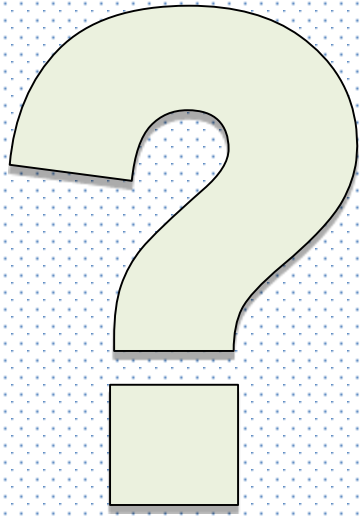


Solution :

	C		H		N
Mole ratio	$\frac{38.8}{12}$	:	$\frac{16}{1}$	:	$\frac{45.2}{14}$
	3.2	:	16	:	3.2
	1	:	5	:	1

Empirical Formula $\Rightarrow CH_5N$

ILLUSTRATIONS

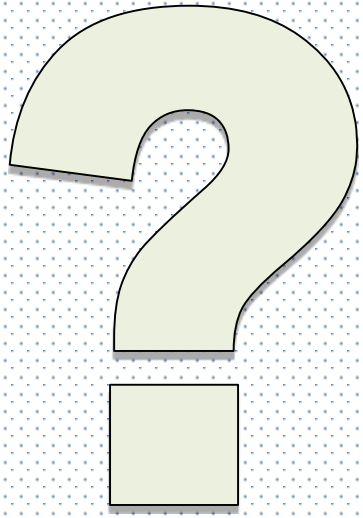


Question : The empirical formula and molecular mass of a compound are CH_2O and 180 a.m.u. respectively. What will be the molecular formula of the compound ?

(1) $C_9H_{18}O_9$ (2) CH_2O

(3) $C_6H_{12}O_6$ (4) $C_2H_4O_2$

ILLUSTRATIONS



Question : The empirical formula and molecular mass of a compound are CH_2O and 180 a.m.u. respectively. What will be the molecular formula of the compound ?

(1) $C_9H_{18}O_9$ (2) CH_2O

(3) $C_6H_{12}O_6$ (4) $C_2H_4O_2$

Solution : Empirical formula weight = 30

Molecular formula weight = 180

$n = 6$

Molecular formula = $(\text{Empirical formula})_n$

$= (CH_2O)_6$

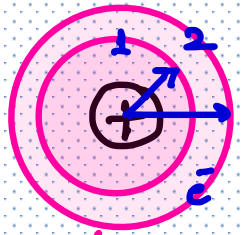
$= C_6H_{12}O_6$

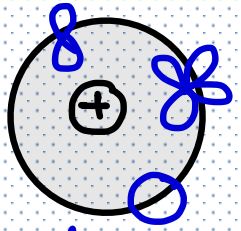
HW → Race - 3 Complete → Illustration before B.B.3

→ B.B-03 Complete

SOME IMPORTANT DEFINITIONS

(Basics of Atomic structure)

Atom → 

→  → each subshell made of some orbitals.

↳ shells | orbits.

- As we go away from Nucleus.
- energy of e⁻ increases
- velocity decreases.

→ Size of shell increase

↓ each contains subshell or sub orbit

↓ space where electron resides

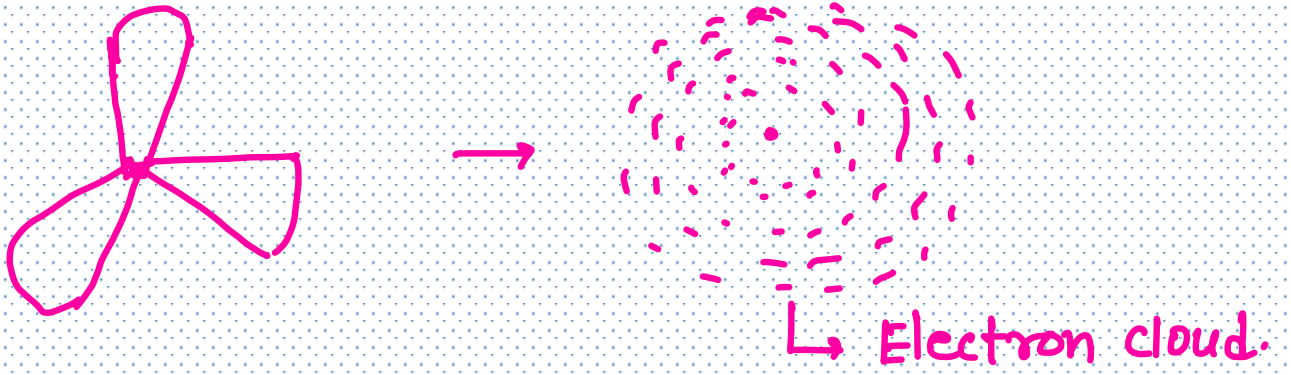
SOME IMPORTANT DEFINITIONS

÷ All shells are Circular . K, L, M, N, O ....
1 2 3 4 5 ....

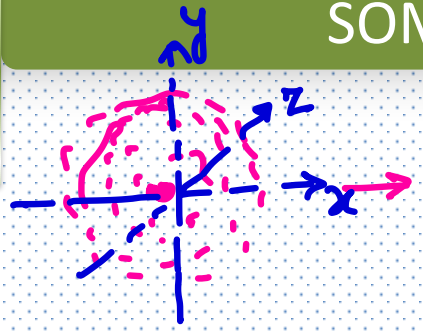
- Subshells
  - s - subshell — spherical
  - p - subshell — dumb-bell
  - d - subshell — double-dumb-bell (lobes)
  - f → Complex.

SOME IMPORTANT DEFINITIONS

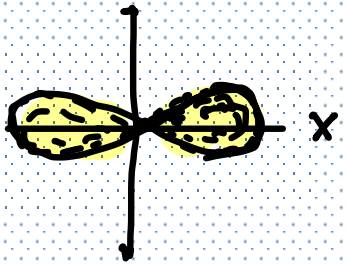
orbital / electron cloud orientation :



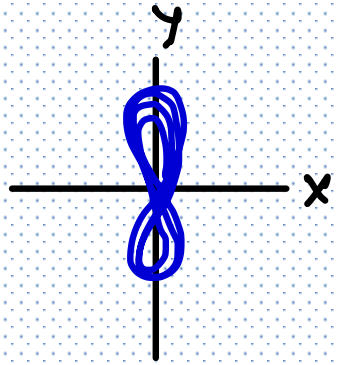
SOME IMPORTANT DEFINITIONS



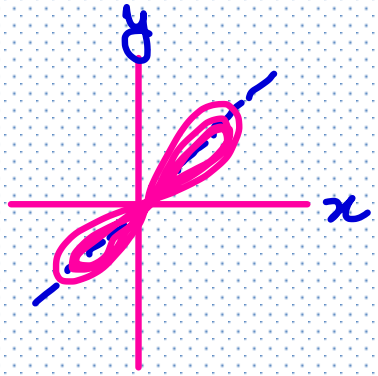
s- orbital



Px orbital

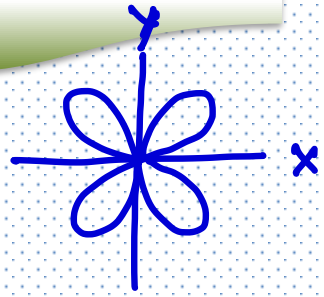


Py orbital

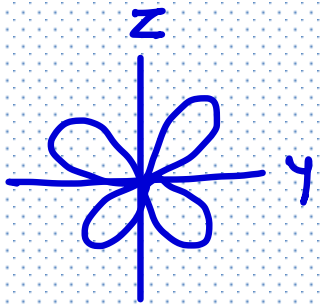


Pz- orbital.

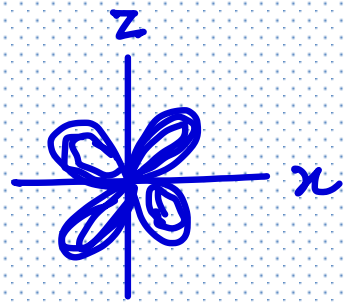
SOME IMPORTANT DEFINITIONS



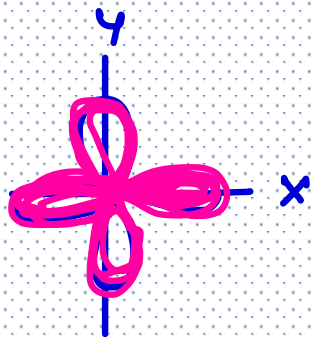
d_{xy}



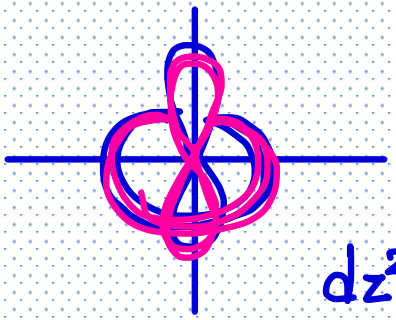
d_{yz}



d_{xz}



$d_{x^2-y^2}$



d_{z^2}