

## Mole Concept

## SOME IMPORTANT DEFINITIONS

Ex. Find the %  $H_2O$  in gypsum salt



$$40 + 32 + 64 + 2 \times 18 =$$

$$136 + 36 = 172$$

$$\% H_2O = \frac{18 \times 2}{172} \times 100$$

Ex. If mass of epsom salt ( $MgSO_4 \cdot xH_2O$ ) has %  $H_2O$  is 60% find no of hydrated water.

$$\cancel{60\%} = \frac{18 \cdot x}{120 + 18x} \times 100 \Rightarrow 30x = 120 + 18x$$
$$12x = 120$$
$$x = 10$$

# Mole Concept

## ILLUSTRATIONS

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

**Solution :**

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

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

$$\checkmark n_{\text{H}_2\text{O}} = \frac{3.6}{18} = 0.2$$

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

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

$$\begin{aligned} \text{No of atom} &= \text{moles of H}_2\text{O} \times N_A \times \text{atomicity} \\ &= 0.2 \times N_A \times 3 \\ &= 0.6 N_A \quad \text{Ans.} \end{aligned}$$



### Percentage Composition:

1 mole CH<sub>4</sub>

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

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

Mass % of element in compound

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

# Mole Concept

## MOLE

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

Mass % of element in compound

$$\begin{array}{l} \text{\% Comp.} = \frac{1 \times \text{At. wt. of element}}{\text{Min. molecule wt.}} \times 100 \end{array}$$

minimum atom = 1  
↓  
Atomicity  
= 1

# Mole Concept

## ILLUSTRATIONS

**Question :** Determine the mass % of each element in  $\text{Fe}_2(\text{SO}_4)_3$ .

$$\begin{aligned} 56 \times 2 + 96 \times 3 &= 0 \\ 112 + 288 &= 400 \end{aligned}$$

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

$$\% \text{ Fe} = 28 \%$$

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

$$\begin{aligned} \% \text{ O} &= 100 - 28 - 24 \\ &= 48 \% \end{aligned}$$



**Question :** Determine the mass % of each element in  $\text{Fe}_2(\text{SO}_4)_3$ .

**Solution :**

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

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

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



# Mole Concept

## ILLUSTRATIONS

(2M+60)

**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.

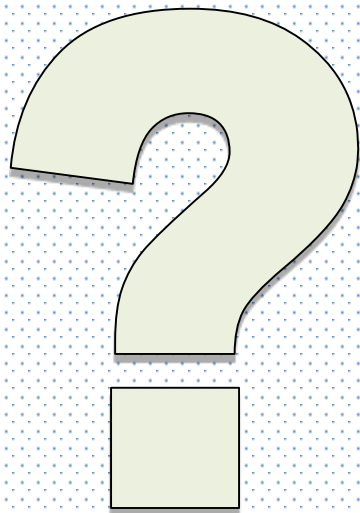
$$\% O = \frac{\cancel{16 \times 3}}{2M + 60} \times 100 = \cancel{48}$$

$$2M + 60 = 100$$

$$2M = 40$$

$$M = 20 \text{ g/mol.}$$





**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 =  $\frac{\text{Atomicity} \times \text{Atomic weight}}{\text{Molecular weight}} \times 100$

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

$$M_w = 100$$

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

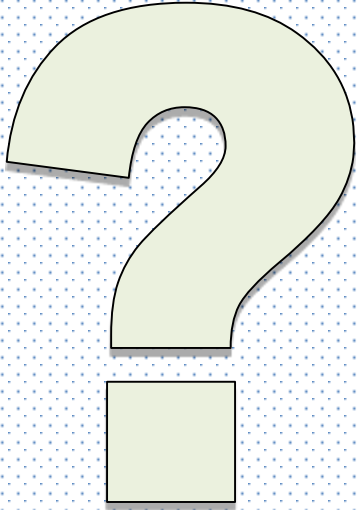
$$M = 20$$



# Mole Concept

## ILLUSTRATIONS

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


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

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

$$\text{Minimum molecular mass} = 50 \text{ g/mol.}$$

# Mole Concept

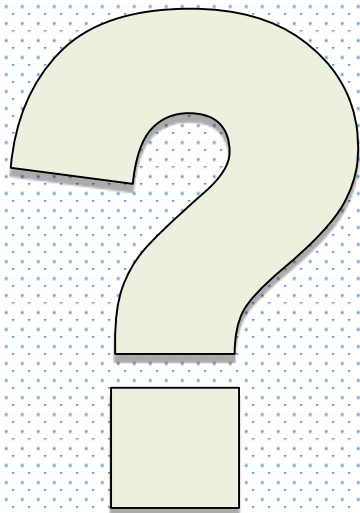
## ILLUSTRATIONS

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

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

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

$$\text{Minimum Mw} = 50$$



# Mole Concept

## 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.



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

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

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

# Mole Concept

## 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 =  $\frac{1 \times \text{Atomic weight}}{\text{Minimum molecular weight}} \times 100$

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

$$\text{Minimum Mw} = 10^4$$

**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.



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

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

$$\underline{x = 4}$$

# Mole Concept

## ILLUSTRATIONS

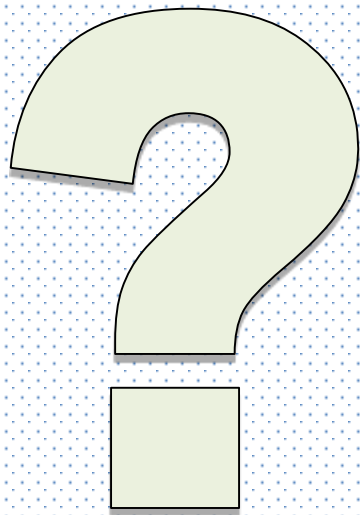
**Question :** How many number of iron atoms will be present in Haemoglobin if its molecular mass is 80000 in which 0.28% iron atoms are present. Atomic mass of iron is 56.

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

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

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

$$\underline{x = 4}$$



# Mole Concept

## 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.



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

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

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

# Mole Concept

## 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 =  $\frac{\text{Atomicity} \times \text{Atomic weight}}{\text{Molecular weight}} \times 100$

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

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

$$\text{Mw} \approx 3650$$



# Mole Concept

## ILLUSTRATIONS

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



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

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

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

# Mole Concept

## 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 =  $\frac{\text{Atomicity} \times \text{Atomic weight}}{\text{Molecular weight}} \times 100$

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

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

$$= 4.2 \times 5$$

$$= 21$$

21



## SOME IMPORTANT DEFINITIONS

### Mole Concept

Ex. Find the change in % of N 14 from  $\text{NH}_3$  all hydrogen are replaced deuterium  $\text{ND}_3$

$$\% \text{ N in } \text{NH}_3 = \frac{14}{17} \times 100 = 82.35\%$$

$$\% \text{ N in } \text{ND}_3 = \frac{14}{20} \times 100 = 70\%$$

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

### Chemical Formula of a Compound

#### Molecular Formula :

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

glucose



6 : 12 : 6

1 : 2 : 1

#### Empirical Formula :

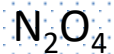
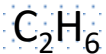
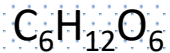
Shows the simplest ratio of all the atoms in a molecule.



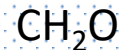
# Mole Concept

## MOLE

### Molecular Formula

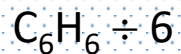


### Empirical Formula



### Example :

**MF**



$$\text{Mw} = 78$$

**EF**



$$\text{EFw} = 13$$

# Mole Concept

## SOME IMPORTANT DEFINITIONS

	M.F	Molecular mass	E.F	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	$CH_3COOH$ <u><math>C_2H_4O_2</math></u>	60	<u><math>CH_2O</math></u>	30

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

## Mole Concept

## 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  $\text{CH}_2$  and its molecular mass is 56. What will be the molecular formula of the compound?

$$\text{Empirical formula mass} = 12 + 2 = 14$$

## Mole Concept

## SOME IMPORTANT DEFINITIONS

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

$$MF = n [EF]$$

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

Exo 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	$\frac{75}{12} = 6.25$	$\frac{6.25}{6.25} = 1$

$CH_4$



# Mole Concept

## 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.

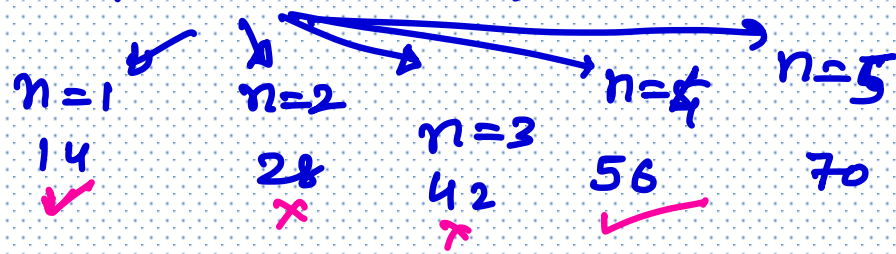
Element	mole	SR
C	33.33	1
H	66.67	2

Ans = C<sub>4</sub>H<sub>8</sub>

Empirical formula CH<sub>2</sub>

$$MF = n(CH_2)$$

$$M_{\text{mass}} = n(14)$$



# Mole Concept

## 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



# SOME IMPORTANT DEFINITIONS

## Mole Concept

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

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

$$\underline{M = 48}$$

2nd oxide

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

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

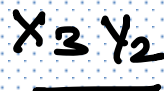


## Mole Concept

### 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



# Mole Concept

## SOME IMPORTANT DEFINITIONS

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

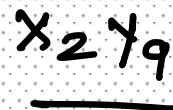
E	mass	mole	SR
X	10	$10/20 = 0.5$	1
Y	90	$\frac{90}{40} = 2.25$	4.5

$$= 2$$

$\times 2$

$$= 9$$

$1.1 \approx 1$   
 $1.3 \approx 1$   
 $1.9 \approx 2$   
 $1.5 \times 2$



### Hw Question ÷

- i) If a compound contains 48% Carbon and oxygen each remaining is hydrogen Find
  - i) Empirical formula.
  - (ii) If compound is disintegrated into its element 224 L of hydrogen is produced find molecular formula.

## Mole Concept

### SOME IMPORTANT DEFINITIONS

② If a given sample of compound contains 9.81 g Zinc,  $1.08 \times 10^{23}$  atom of chromium and 0.06 gram atom of oxygen find empirical formula.

## SOME IMPORTANT DEFINITIONS

### Mole Concept

③ A gaseous 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.



## Mole Concept

### 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.

## Mole Concept

### SOME IMPORTANT DEFINITIONS

- A gaseous hydrocarbon when burnt gave 0.72g  $\text{H}_2\text{O}$  and 3.08g  $\text{CO}_2$  find empirical formula of compound.

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

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

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

### Determination of Empirical Formula:

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

### 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 mass is 60.

### Solution:

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

### Simplest Molar Ratio :

$$\begin{aligned}\text{C} : \text{O} : \text{N} : \text{H} &= 1.66 : 1.66 : 3.33 : 6.67 \\ &= 1.66/1.66 : 1.66/1.66 : 3.33/1.66 : 6.67/1.66 \\ &= 1 : 1 : 2 : 4\end{aligned}$$

So Empirical Formula =  $\text{CON}_2\text{H}_4$

Now,  $\text{EF}_w = 60$        $n = \frac{\text{MF}_w}{\text{EF}_w} = 1$

$$\text{MF}_w = 60$$

$$\text{MF} = (\text{CON}_2\text{H}_4)_1$$

### 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 <sub>2</sub>
	1	:	2	

### 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





**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 :**





**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  $\Rightarrow$   $\text{H}_4\text{CON}_2$

# Mole Concept

## ILLUSTRATIONS

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



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**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  $\Rightarrow \text{C}_5\text{O}_2\text{H}_8$



# Mole Concept

## ILLUSTRATIONS

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



# Mole Concept

## ILLUSTRATIONS

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

**Solution :**

	P		O
Mole ratio	$\frac{1.5 \times 10^{21}}{6 \times 10^{23}}$	:	$\frac{37.5 \times 10^{20}}{6 \times 10^{23}}$
Mole ratio	2	:	5

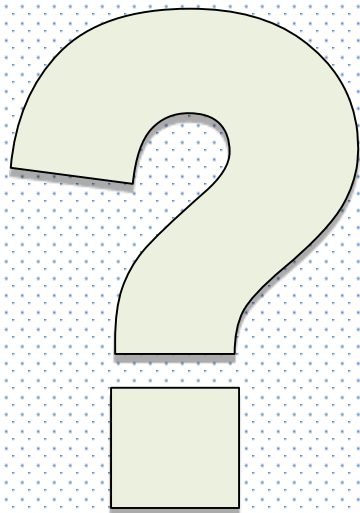
Empirical Formula  $\Rightarrow \text{P}_2\text{O}_5$



# Mole Concept

## 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.



# Mole Concept

## 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 =  $6x$

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

	<i>C</i>		<i>H</i>		<i>N</i>
<i>Mole ratio</i>	$\frac{6x}{12}$	:	$\frac{x}{1}$	:	$\frac{7x}{1.5 \times 14}$
<i>Mole ratio</i>	3	:	6	:	2

Empirical Formula  $\Rightarrow \text{C}_3\text{H}_6\text{N}_2$

# Mole Concept

## ILLUSTRATIONS

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





# Mole Concept

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

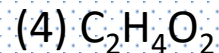
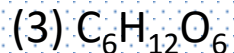
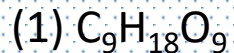


**Solution :**

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

Empirical Formula  $\Rightarrow \text{CH}_5\text{N}$

**Question :** The empirical formula and molecular mass of a compound are  $\text{CH}_2\text{O}$  and 180 a.m.u. respectively. What will be the molecular formula of the compound ?

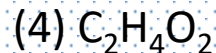
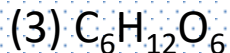
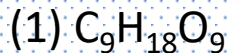


# Mole Concept

## ILLUSTRATIONS



**Question :** The empirical formula and molecular mass of a compound are  $\text{CH}_2\text{O}$  and 180 a.m.u. respectively. What will be the molecular formula of the compound ?



**Solution :** Empirical formula weight = 30  
Molecular formula weight = 180

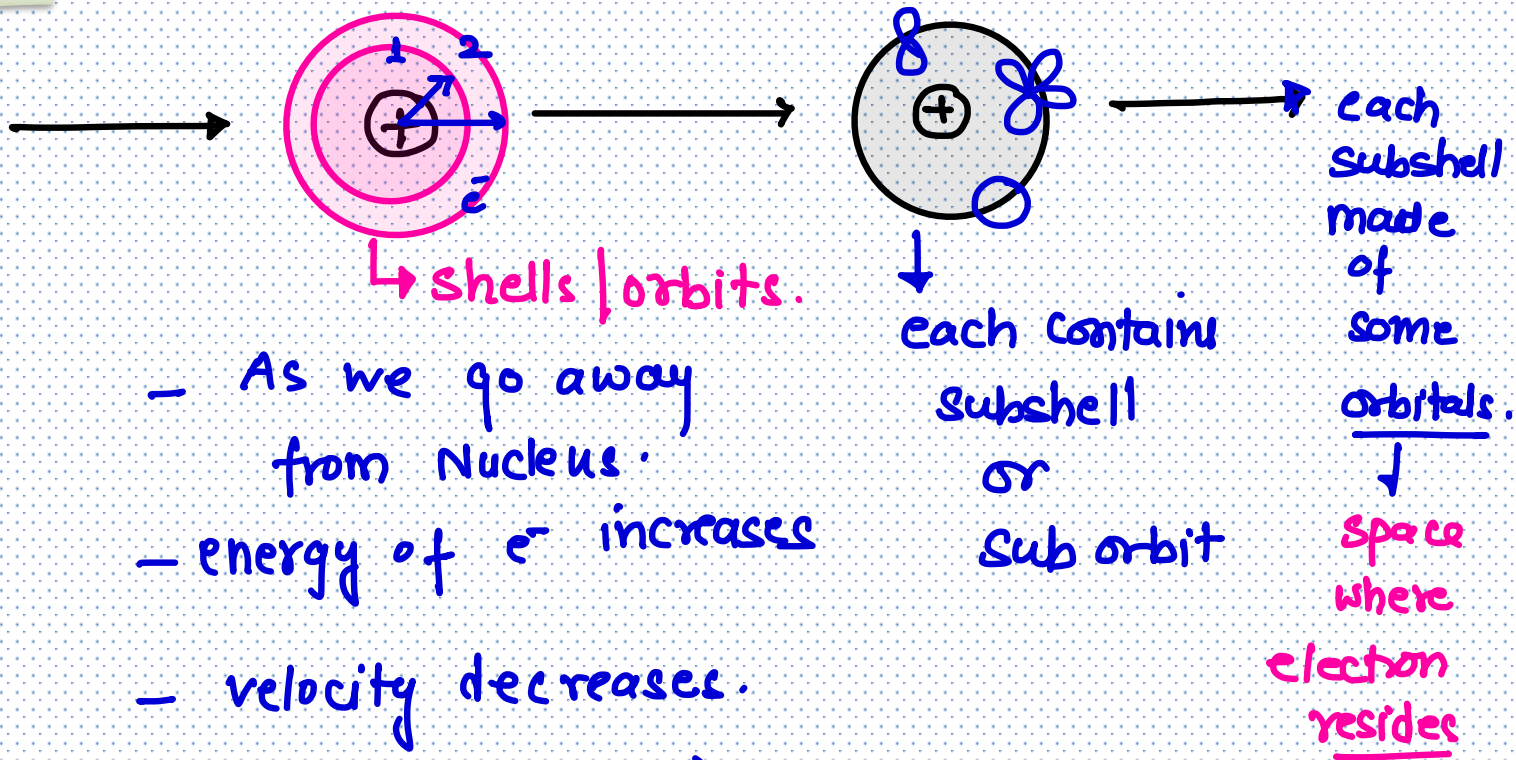
$$n = 6$$

$$\begin{aligned}\text{Molecular formula} &= (\text{Empirical formula})_n \\ &= (\text{CH}_2\text{O})_6 \\ &= \text{C}_6\text{H}_{12}\text{O}_6\end{aligned}$$

HW → Race - 3 Complete → illustration before B.B.3  
→ B.B - 03 Complete

### (Basics of Atomic structure)

Atom

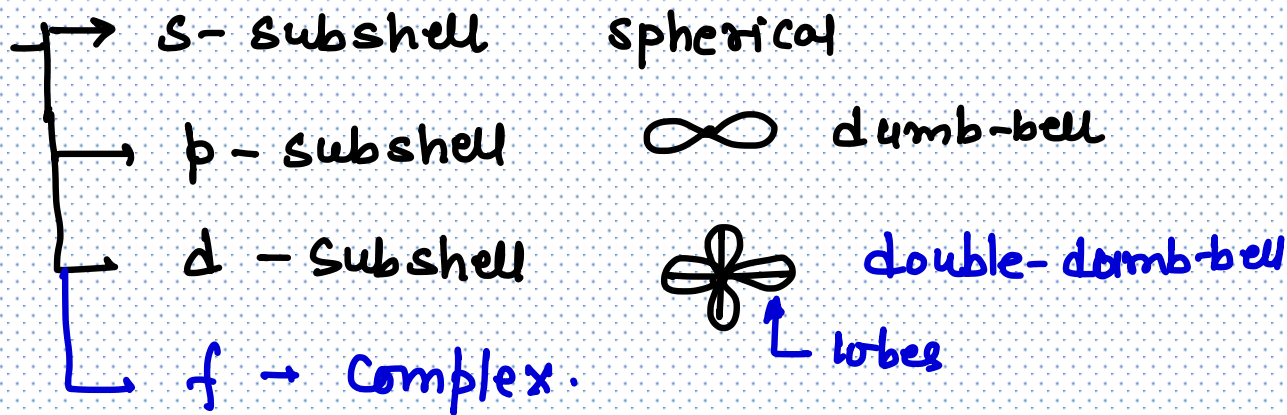


# Mole Concept

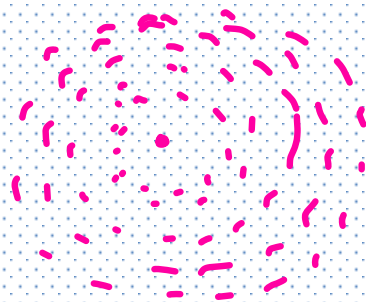
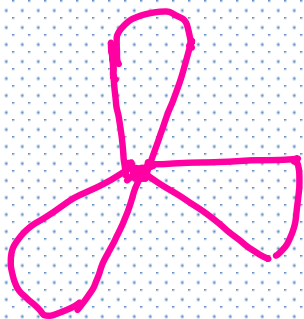
## SOME IMPORTANT DEFINITIONS

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

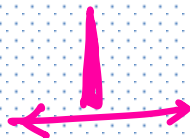
### • Subshells



orbital / electron cloud orientation ÷

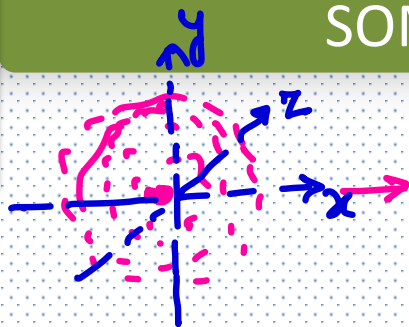


↳ Electron cloud.

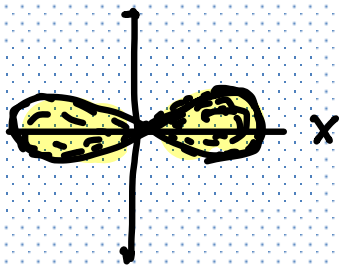


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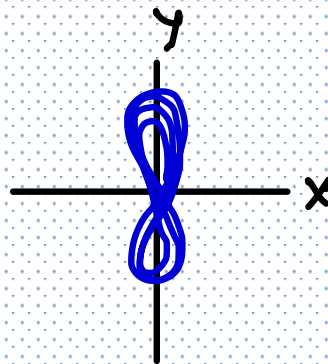
## SOME IMPORTANT DEFINITIONS



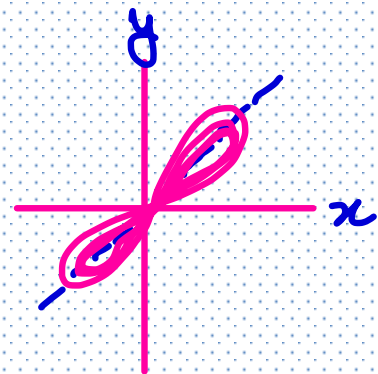
s-orbital



$p_x$  orbital



$p_y$  orbital



$p_z$ -orbital.

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## SOME IMPORTANT DEFINITIONS

