



# NEET - UG

NATIONAL TESTING AGENCY

## Chemistry

Physical Chemistry - 1



# INDEX

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## Physical Chemistry - 1

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## Basic Concepts of Chemistry

### # The International System of Units

Base Physical Quantity	Symbol for Quantity	Name of SI Unit	Symbol for SI Unit
Length	$l$	Metre	m
Mass	$m$	Kilogram	kg
Time	$t$	Second	s
Electric current	$I$	Ampere	A
Thermodynamic temperature	$T$	Kelvin	k
Amount of substance	$n$	Mole	mol
Luminous intensity	$I_v$	Candela	cd

### # Significant Figures

#### A. What is a "significant figure"?

The number of significant figures in a result is simply the number of figures that are known with some degree of reliability. The number 13.2 is said to have 3 significant figures. The number 13.20 is said to have 4 significant figures.

#### B. Rules for deciding the number of significant figures in a measured quantity:

- (1) All nonzero digits are significant  
 1.234 g has 4 significant figures,  
 1.2 g has 2 significant figures.
- (2) Zeroes between nonzero digits are significant:  
 1002 kg has 4 significant figures,  
 3.07 mL has 3 significant figures.

- (3) Zeroes to the left of the first nonzero digits are not significant; such zeroes merely indicate the position of the decimal point:

0.001° C has only 1 significant figure,

0.012 g has 2 significant figures.

- (4) Zeroes to the right of a decimal point in a number are significant:

0.023 mL has 2 significant figures,

0.200 g has 3 significant figures.

- (5) When a number ends in zeroes that are not to the right of a decimal point, the zeroes are not necessarily significant:

190 miles may be 2 or 3 significant figures, 50, 600 calories may be 3, 4, or 5 significant figures. The potential ambiguity in the last rule can be avoided by the use of standard exponential, or "scientific," notation. For example, depending on whether 3, 4, or 5 significant figures is correct, we could write 50, 6000 calories as:

$5.06 \times 10^4$  calories (3 significant figures)

$5.060 \times 10^4$  calories (4 significant figures), or

$5.0600 \times 10^4$  calories (5 significant figures).

### C. What is a "exact number"?

Some numbers are exact because they are known with complete certainty.

Most exact numbers are integers : exactly 12 inches are in a foot, there might be exactly 23 students in a class. Exact numbers are often found as conversion factors or as counts of objects.

Exact numbers can be considered to have an infinite number of significant figures. Thus, number of apparent significant figures in any exact number can be ignored as a limiting factor in determining the number of significant figures in the result of a calculation.

### D. Rules for mathematical operations

In carrying out calculations, the general rule is that the accuracy of a calculated result is limited by the least accurate measurement involved in the calculation.

- (1) In addition and subtraction, the result is rounded off to the last common digit occurring furthest to the right in all components. For example, 100 (assume 3 significant figures) + 23.643 (5 significant figures) = 123.643, which should be rounded to 124 (3 significant figures).

- (2) In multiplication and division, the result should be rounded off so as to have the same number of significant figures as in the component with the least number of significant figures. For example, 3.0 (2 significant figures) 12.60 (4 significant figures) = 37.8000 which should be rounded off to 38 (2 significant figures).

### E. Rules for rounding off numbers

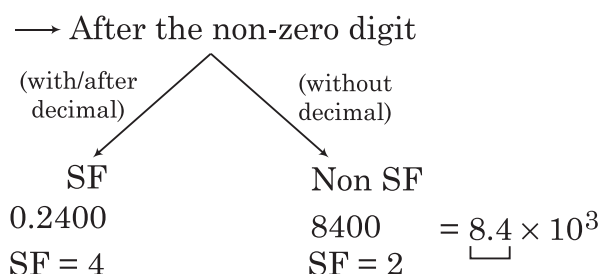
- (1) If the digit to be dropped is greater than 5, the last retained digit is increased by one. For example, 12.6 is rounded to 13.
- (2) If the digit to be dropped is less than 5, the last remaining digit is left as it is. For example, 12.4 is rounded to 12.
- (3) If the digit to be dropped is 5, and if any digit following it is not zero, the last remaining digit is increased by one. For example, 12.51 is rounded to 13.
- (4) If the digit to be dropped is 5 and is followed only by zeroes, the last remaining digit is increased by one if it is odd, but left as it is if even. For example, 11.5 is rounded to 12, 12.5 is rounded to 12.

This rule means that if the digit to be dropped is 5 followed only by zeroes, the result is always rounded to the even digit. The rationale is to avoid bias in rounding: half of the time we round up, half the time we round down.

1. Non-zero digits = SF.

2. Zero → between non-zero digits = SF

→ between decimal and non-zero digit = not SF



→ Shows accuracy.

3. With unit → SF (shows measurement)

$$8400 \text{ cm} \rightarrow \text{SF} = 4 \Rightarrow S \leq 4$$

$$8.4 \times 10^3 \text{ cm} \rightarrow \text{SF} = 2$$

$$8.4 \times 10^3 \text{ cm} \rightarrow \text{SF} = 3$$

$$8.400 \times 10^3 \text{ cm} \rightarrow \text{SF} = 4$$

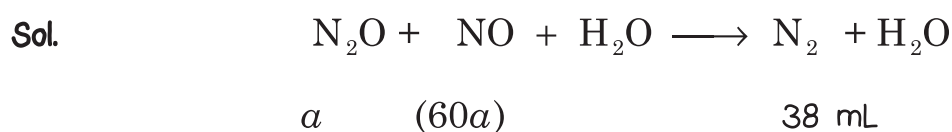
	SF	Rounding off :
E.g., 123	3	$\Rightarrow$ Removing last (uncertain) digit
12.3	3	<i>E.g.,</i>
12.34	4	27.326 $\rightarrow$ 27.33
1.203	4	27.33 $\rightarrow$ 27.3
1.203	4	27.535 $\rightarrow$ 27.54
1.002	4	27.545 $\rightarrow$ 27.54
1.0024	5	
0.024	2 [= 2.4 $\times 10^{-3}$ ]	
0.0024	2	

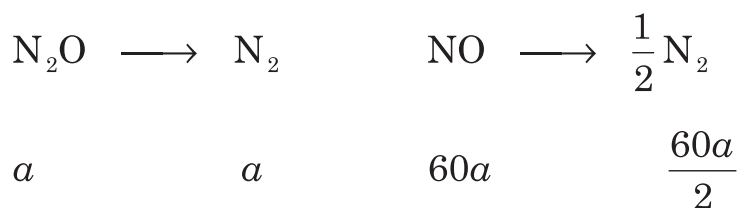
## # Calculation of Digits

1. Addition/subtraction  $\rightarrow$  Least number of decimal digits in answer.

2. Multiple/Division  $\rightarrow$  Least number of significant figures in answer.

Q. 60 mL of a mixture of nitrous oxide and nitric oxide was exploded with excess of  $\text{H}_2$ . If 38 mL of  $\text{N}_2$  is formed, then calculate volume composition of the mixture.





$$a + \frac{60 - a}{2} = 38$$

$$2a + 60 - a = 76 \Rightarrow a = 16$$



## # Laws of Chemical Combination

### A. Law of conservation of Mass :

Given by Lavoisier (1776).

According to this law, during a physical or chemical change, total mass of the substance is conserved.

or

weight of product formed is always equal to weight of reactants reacted.

### 1. Physical Change



Total wt. of water = wt. of Ice

### 2. Chemical Change



wt. of P formed = wt. of R reacted

### 3. Exception : Nuclear Reactions

where,

$$E = MC^2$$

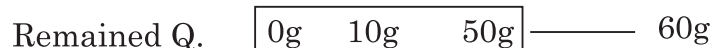
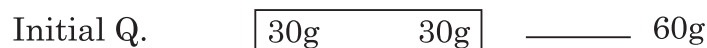
$M$  = decay in mass

$C$  = light velocity

$$\text{If } m = 1 \text{ amu} = 1.67 \times 10^{-24} \text{ g} = 1.67 \times 10^{-27} \text{ kg}$$



$$\epsilon = 931 \text{ MeV}$$

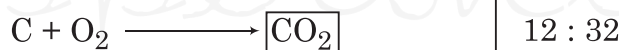


### B. Law of constant Proportion : [Law of definite proportions]

Given by Proust.

According to this law, all pure samples of a compound contain same elements in definite proportions of their mass.

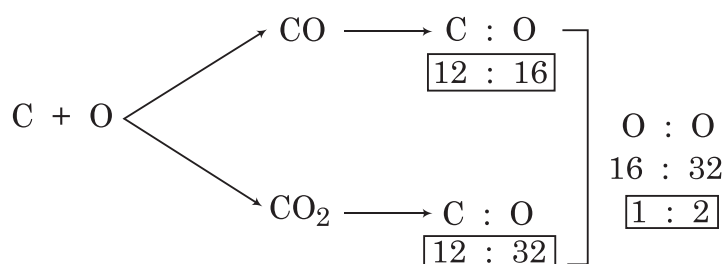
E.g.,  $\text{CO}_2$



### C. Law of Multiple Proportion :

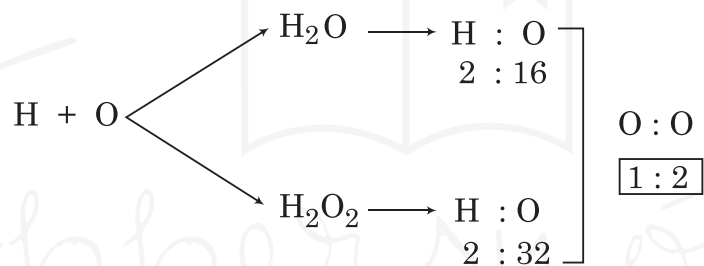
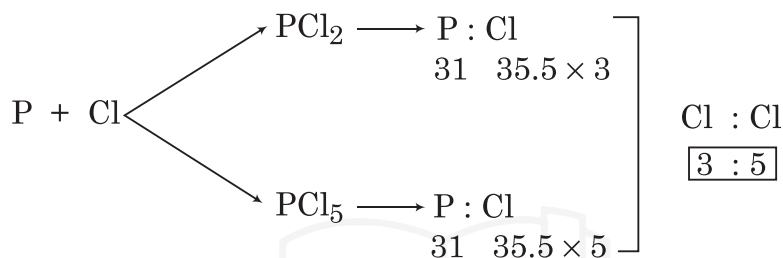
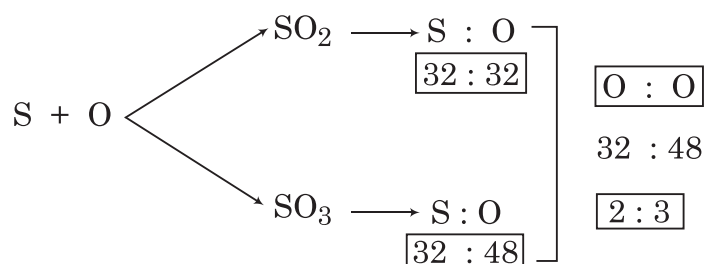
Given by Dalton

E.g.,



According to this law, when 2 elements combine together and form more than 1 type of molecules, the different masses of 1 element which combine with the same mass of other element are in simple ratio.

E.g.,

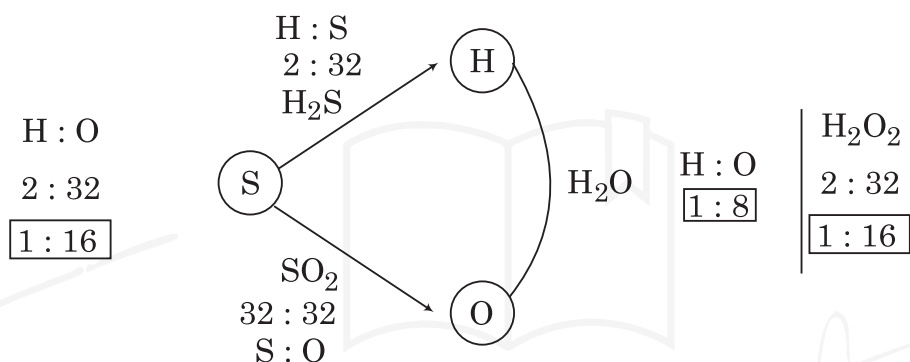
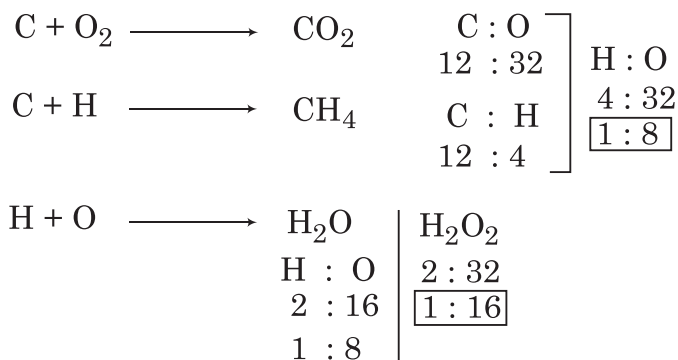


	N	O	Ratio of O
$\text{N} + \text{O} \rightarrow \text{N}_2\text{O}$	28	16	1
$\text{N} + \text{O} \rightarrow (\text{NO})_2$	$14 \times 2$ 28	$16 \times 2$ 32	2
$\text{N} + \text{O} \rightarrow \text{N}_2\text{O}_3$	28	48	3
$\text{N} + \text{O} \rightarrow \text{N}_2\text{O}_4$	28	64	4
$\text{N} + \text{O} \rightarrow \text{N}_2\text{O}_5$	28	80	5

#### D. Law of Reciprocal Proportion :

Given by Richter.

According to this law when 2 elements A and B separately combine with a fixed mass of 3rd element C, then the combining ratio of A and B can be achieved if they combined directly.



Q. In which of the following set of molecular L of RP is applicable?

1.  $\text{H}_2\text{S}$ ,  $\text{SO}_2$  and  $\text{SO}_3$ .
2.  $\text{NaCl}$ ,  $\text{KCl}$  and  $\text{HCl}$ .
3.  $\text{PH}_3$ ,  $\text{P}_2\text{O}_3$  and  $\text{P}_2\text{O}_5$ .
4.  $\text{PH}_3$ ,  $\text{P}_2\text{O}_3$  and  $\text{H}_2\text{O}$ .

**Ans.** Option (4) i.e.,  $\text{PH}_3$ ,  $\text{P}_2\text{O}_3$  and  $\text{H}_2\text{O}$ .

### E. Law of Gaseous Volumes :

Given by Gay Lussac.

According to this law, under similar conditions of temperature and pressure in a reaction, volume ratio of gaseous components is always simple ratio.

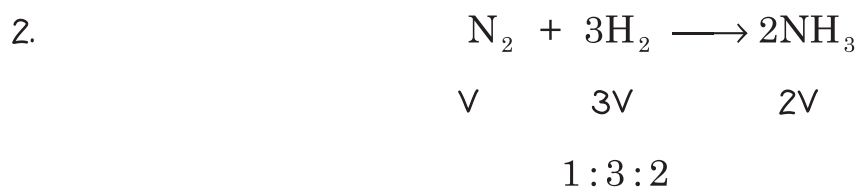
E.g., 1.



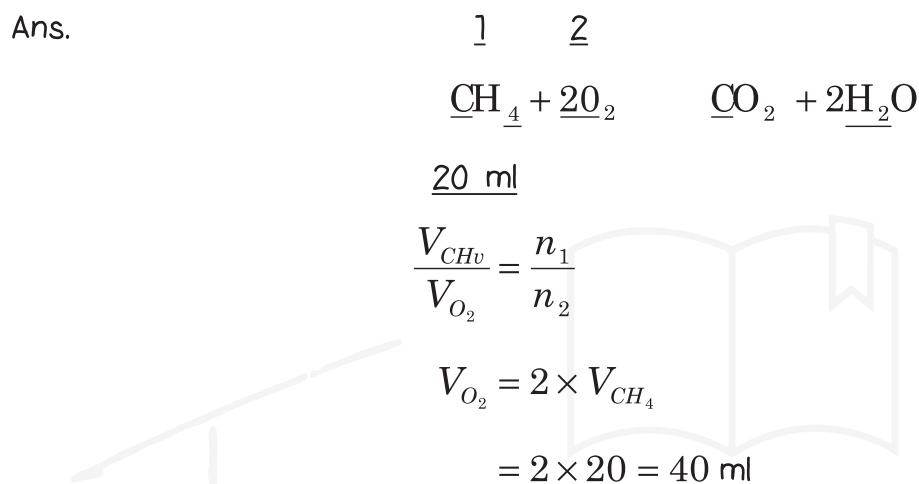
(g) (g)

v v 2v

1:1:2

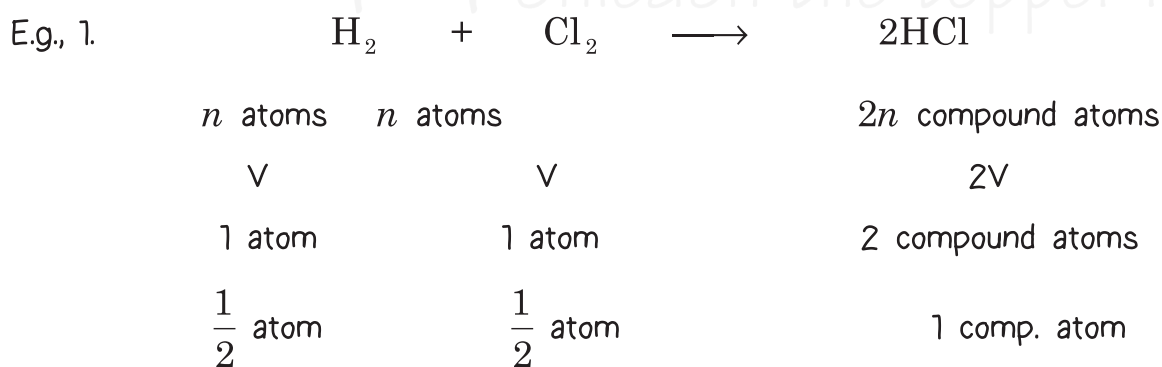


Q. What Vol, of  $\text{O}_2$  is required for complete combustion of 20 ml  $\text{CH}_4$  gas

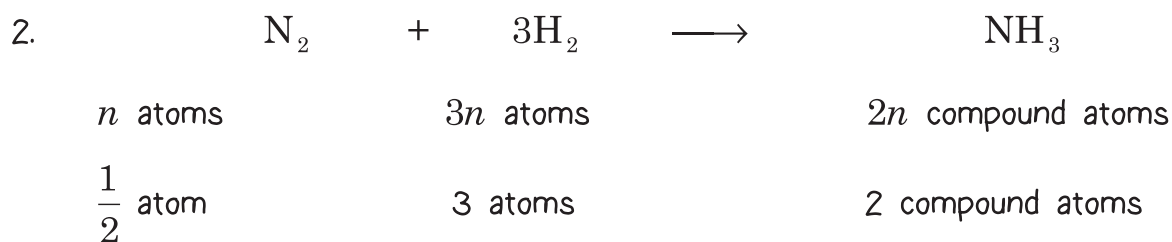


### F. Berzelius Hypothesis

Under the similar conditions of temperature and pressure, equal volumes of all gases contain the same number of atoms.



But this is against Dalton's law.



$$\frac{1}{2} \text{ atoms}$$

$$\frac{3}{2} \text{ atoms}$$

1 compound atoms

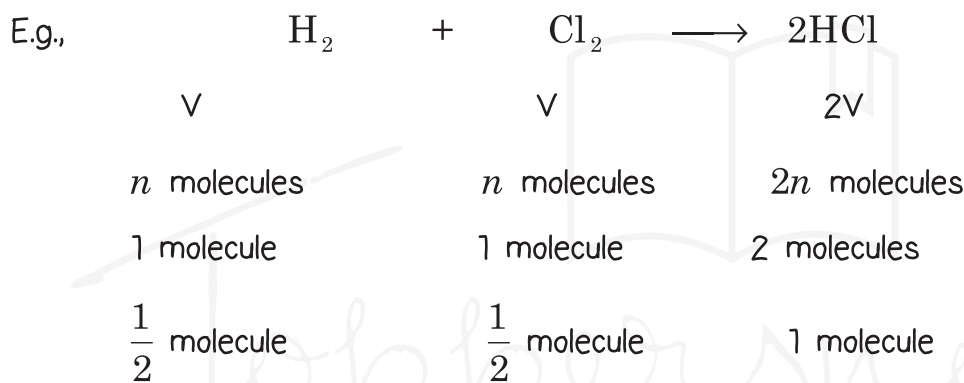
Again, this is against the Dalton Law.

### G. Avogadro Hypothesis

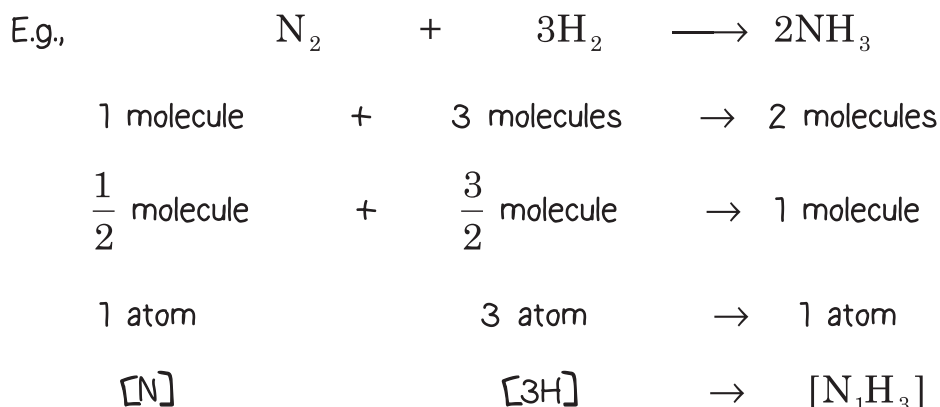
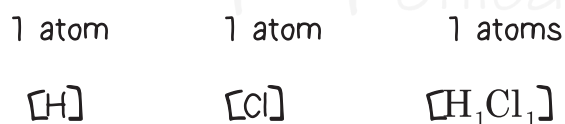
Avogadro introduced a new intermediate particle, "molecule".

Under similar conditions of temperature and pressure, equal volumes of all gases contains the same no. of molecules.

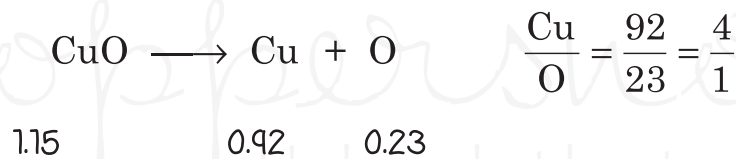
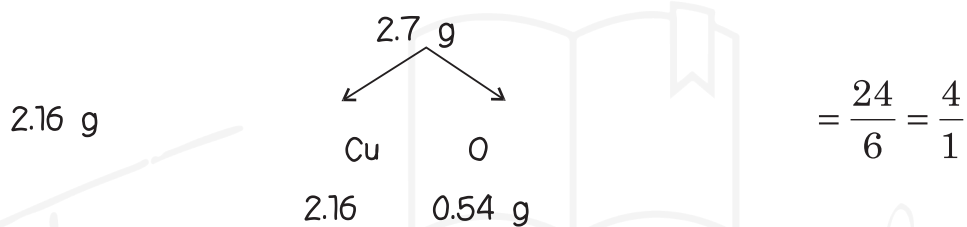
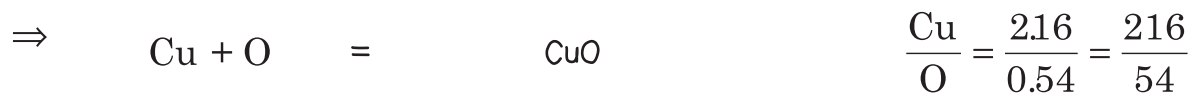
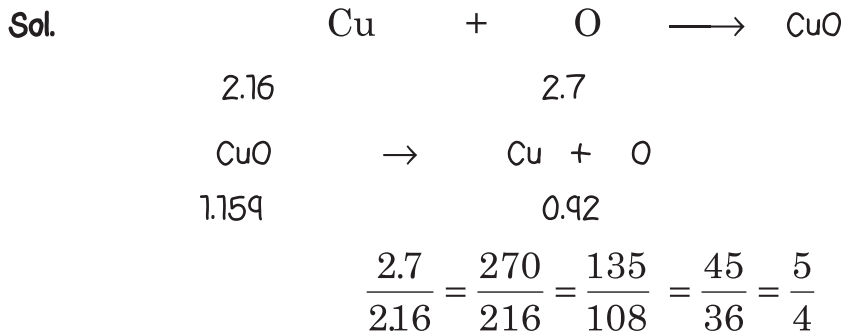
Gas  $\longrightarrow$  Molecule  $\longrightarrow$  Atom



If  $\text{H}_2$  and  $\text{Cl}_2$  is diatomic

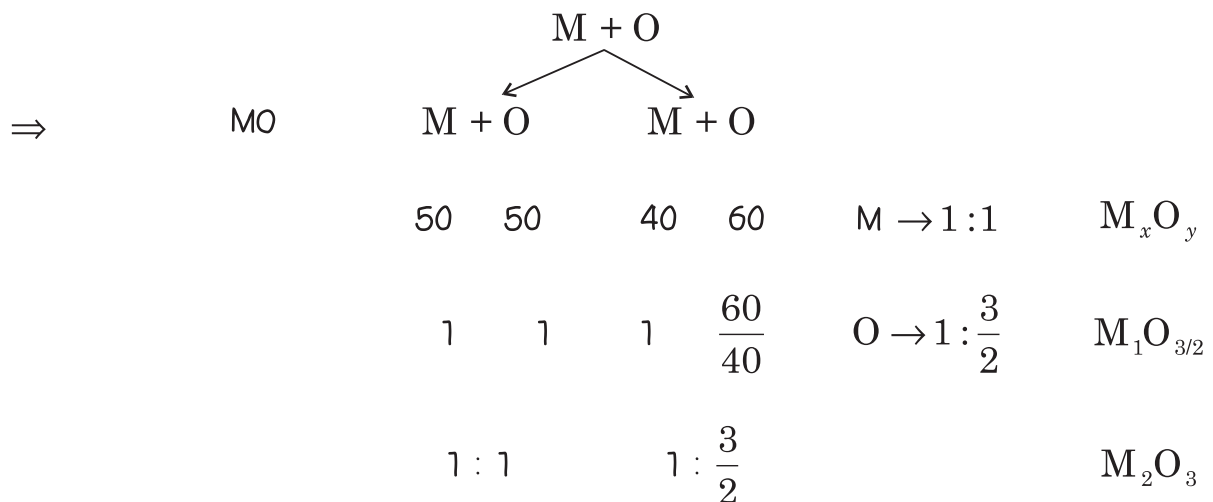


Q. 2.16 g metallic Cu forms 2.7 g CuO on heating in oxygen. In another experiment, 1.15 g CuO on reduction forms 0.92 g Cu. Show that these observations are according to law of definite proportions.



Q. One metal forms 2 oxides, which contains 50% and 60% oxygen. If formula of first oxide in MO, then formula of 2nd oxide will be :

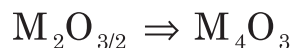
1.  $M_2O$     2.  $MO_2$     3.  $M_2O_3$     4. None of these



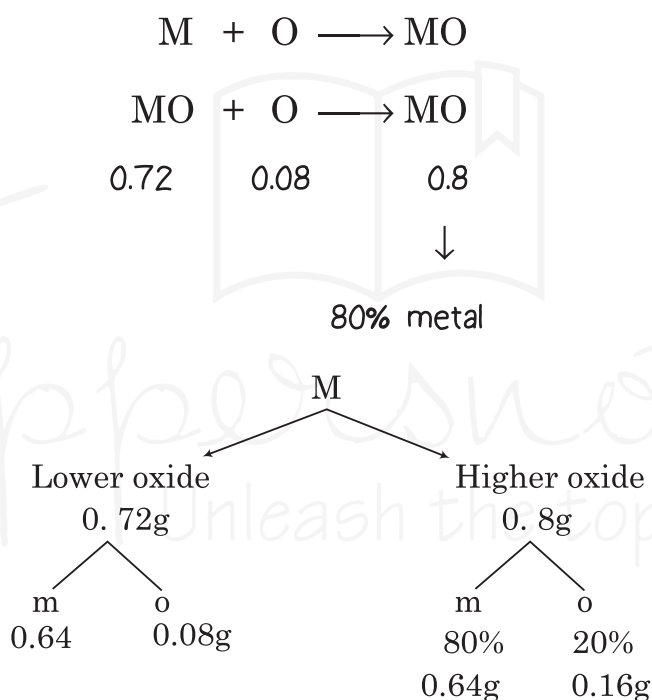
1 : 1

2 : 3

$M_2O_{3 \times 3/2}$



Q. One metal forms 2 oxides. Higher oxide contains 80% of metal, 0.72 g of lower oxide on oxidation forms 0.8 g of higher oxide, show that these observations are according to law of multiple proportions.

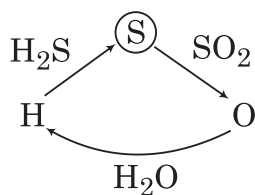


$$\frac{80}{100} \times \frac{0.8}{10} = 0.64 \text{ gM}$$

$$\frac{0.08}{0.16} = \frac{1}{2}$$

$\Rightarrow$  Law of multiple proportions Proved.

Q.  $H_2S$  contains 94.11% of S,  $SO_2$  contains 50% of O and  $H_2O$  contains 11.11% of H. Show that these observations are according to law of reciprocal proportions.



$$1 : \frac{5.89}{9411} \qquad 1 : 1$$

$$1 : \frac{1}{16} \qquad 1 : 1$$

11.11% H + 88.89% O

$$\text{H} : \text{O} = \frac{1}{16} : 1 \Rightarrow 1 : 16$$

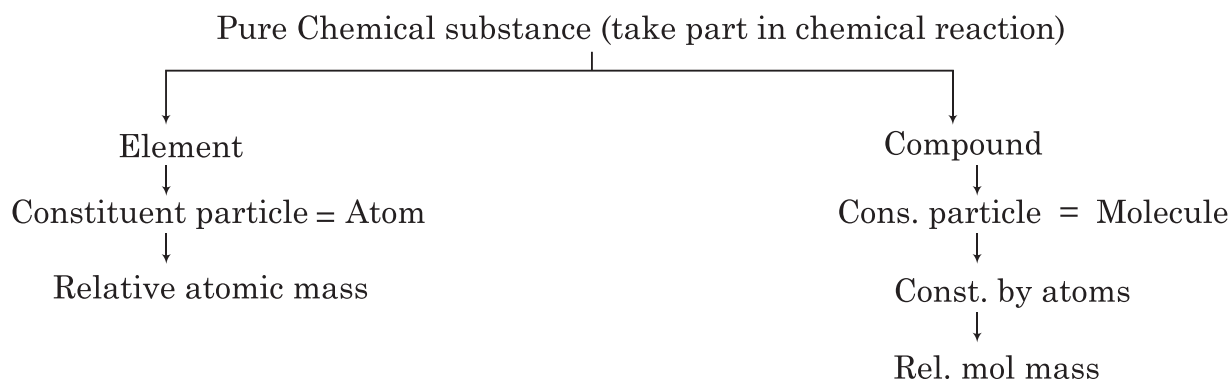
H : O

$$\text{H} : \text{O} \Rightarrow 11.11 : 88.89 \Rightarrow 1 : \frac{88.89}{11.11} = 1 : 8$$

$$\therefore \frac{1 : 16}{1 : 8} = \frac{2}{1} = 2 : 1$$

## # Mole

\* It is a measuring unit of quantity of chemical substances. It is an SI unit. Symbol is mol.







$X_1, X_2$  = Relative occurrence in nature.

E.g.,	${}_{17}\text{Cl}^{35}$	${}_{17}\text{Cl}^{37}$	
	75%	25%	
	3	1	

$$\text{Average mass} = \frac{35 \times 75 + 37 \times 25}{(75 + 25)} = 35.5$$

or

$$\text{Average mass} = \frac{35 \times 3 + 37 \times 1}{(3 + 1)} = 35.5$$

Q. Calculate % of  $B^{10} \times B^{11}$  in nature when average atomic mass of  $B$  is 10.8.

**Ans.** Let relative occurrence of  $B^{10}$  and  $B^{11}$  in nature are  $x\%$  and  $y\%$  respectively, then  
 $x + y = 100$  or  $y = 100 - x$

$$10.8 = \frac{10 \times x + 11 \times y}{x + y}$$

$$10x + 11y = 10.8x + 10.8y$$

$$0.2y = 0.8x$$

$$\frac{x}{y} = \frac{1}{4}$$

$$\% \text{ of } B^{10} = x = \frac{1}{5} \times 100\% = 20\%$$

or

$$\% \text{ of } B^{11} = 80\%$$

$$\frac{10x + 11(100 - x)}{100} = 10.8$$

$$10x + 1100 - 11x = 1080$$

$$x = 20$$

\*  $\text{Br}^{79}$      $\text{Br}^{81}$     Average mass = 80

50%

50%



99.98%



0.016%



$10^{-15}\%$

Average mass = 1