





ii. Molecular formula

15. How many moles of ethane are required to produce 66 g CO<sub>2</sub> after combustion?
16. A solution is prepared by dissolving 150g of NaCl in 900 g of water. Calculate the mole fraction of each component.
17. How many moles of N<sub>2</sub> are required to produce 85g of NH<sub>3</sub>? Calculate its mass.

### **3 Marks**

18. What do you mean by limiting reagent?  
400 g of N<sub>2</sub> and 150 g of H<sub>2</sub> are mixed together to form NH<sub>3</sub>. Identify the limiting reagent and calculate the amount of NH<sub>3</sub> produced.
19. Explain the following:
- Mole fraction
  - Molarity
  - Molality
20. The density of 2M solution of NaCl is 1.25 g ml<sup>-1</sup>. Calculate molality of the solution.
21. Identify the limiting reagent if 0.6g of magnesium is added to 100 ml solution of 0.4M hydrochloric acid. Also Calculate the mass of hydrogen gas produced.  
(Mg = 24u)
22. Caffeine has the following percent composition: carbon 49.48%, hydrogen 5.19%, oxygen 16.48% and nitrogen 28.85%. Its molecular weight is 194.19 g/mol. What is its molecular formula?

### **5 Marks**

23. a. Commercially available conc HCl is in an aqueous solution containing 40% HCl gas by mass. If its density is 1.2 gcm<sup>-3</sup>, calculate the molarity of HCl solution.
- b. Empirical formula of a gaseous compound is CH<sub>2</sub>Cl. 0.12 g of the compound occupies a volume of 37.20cc at 105 degree centigrade and 760 mm Hg. Find the molecular formula of the compound.
- c. State Avogadro law.

### Answers

- a
- b
- c
- $24.088 \times 10^{23}$  atoms
- simple whole number ratio
- b

7. a  
 8. a  
 9. d  
 10. b  
 11. a. A given compound always contains exactly the same proportion of elements by weight.  
 b. If two elements can combine to form more than one compound, the masses of one element that combine with a fixed mass of the other element, are in the ratio of small whole numbers.

12.

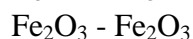
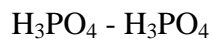
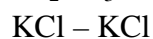
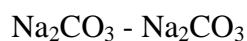
$$\text{Mole fraction of A in solution } (x_A) = \frac{n_A}{n_A + n_B}$$

$$\text{Mole fraction of B in solution } (x_B) = \frac{n_B}{n_A + n_B}$$

So,

$$x_A + x_B = \frac{n_A + n_B}{n_A + n_B} = 1$$

13. CO – CO



14.

Element	Mass	Moles	Ratio	Simplest ratio
C	144	12	1	1
H	12	12	1	1

Empirical formula = CH

Empirical formula mass = 13

$$n = 78/13 = 6$$

Molecular formula = C<sub>6</sub>H<sub>6</sub>

15. C<sub>2</sub>H<sub>6</sub> + 7/2 O<sub>2</sub> → 2CO<sub>2</sub> + 3H<sub>2</sub>O

No: of moles of CO<sub>2</sub> = 66/44 = 1.5 moles

	C <sub>2</sub> H <sub>6</sub>	CO <sub>2</sub>
As per eqn	1 mol	2 mol
As per qsn	?	1.5 mol

Ans: 0.75 moles of ethane.

16.

$$n_{\text{NaCl}} = 150 / 58.5 = 2.56$$

$$n_{\text{H}_2\text{O}} = 900 / 18 = 50$$

$$\chi_{\text{NaCl}} = 2.56 / (2.56 + 50) = 0.0487$$

$$\chi_{\text{H}_2\text{O}} = 50 / 52.56 = 0.951$$

17.  $\text{N}_2 + 3\text{H}_2 \rightarrow 2\text{NH}_3$

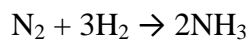
No: of moles of  $\text{NH}_3 = 85/17 = 5$  moles

$\text{N}_2$	$\text{NH}_3$
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As per eqn, 1 mol	2 mol
As per qsn, ?	5 moles

Therefore no: of moles of  $\text{N}_2 = 2.5$  moles

18. Limiting reagent: The reactant, which gets consumed first, limits the amount of product formed and is, therefore, called the limiting reagent.



No: of moles of  $\text{N}_2 = 400/28 = 14.28$  mol

No: of moles of  $\text{H}_2 = 150/2 = 75$  mol

	$\text{N}_2$	$\text{H}_2$
As per eqn.	1	3
As per qsn,	14.28	?

No: of moles of  $\text{H}_2$  required for 14.28 moles of  $\text{N}_2 = 42.84$  mol

Therefore,  $\text{H}_2$  is excess reagent i.e  $\text{N}_2$  is limiting reagent.

	$\text{N}_2$	$\text{NH}_3$
As per eqn.	1	2
As per qsn,	14.28	?

Therefore no: of moles of  $\text{NH}_3 = 28.56$  mol

$$\text{Mass of } \text{NH}_3 = 28.56 \times 17 = 485.52 \text{ g}$$

19. a. Mole fraction : It is the ratio of number of moles of a particular component to the total number of moles of the solution.

Mole fraction of A

$$\begin{aligned} &= \frac{\text{No. of moles of A}}{\text{No. of moles of solutions}} \\ &= \frac{n_A}{n_A + n_B} \end{aligned}$$

Mole fraction of B

$$\begin{aligned} &= \frac{\text{No. of moles of B}}{\text{No. of moles of solutions}} \\ &= \frac{n_B}{n_A + n_B} \end{aligned}$$

b. Molarity : It is defined as the number of moles of the solute in 1 litre of the solution.

$$\text{Molarity (M)} = \frac{\text{No. of moles of solute}}{\text{Volume of solution in litres}}$$

c. Molality: It is defined as the number of moles of solute present in 1 kg of solvent.

$$\text{Molality (m)} = \frac{\text{No. of moles of solute}}{\text{Mass of solvent in kg}}$$

20. Molarity = 2M

Assume volume of solution = 1 L

Therefore, No of moles of NaCl = 2 mol

Mass of NaCl =  $2 \times 58.5 = 117$  g

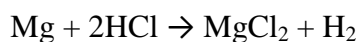
Mass of 1 L of solution =  $1.25 \text{ gml}^{-1} \times 1000\text{g} = 1250$  g.  
(Since density =  $1.25 \text{ gml}^{-1}$  and density = mass / volume)

Mass of water =  $1250 \text{ g} - 117 \text{ g}$   
= 1133 g

Molality = No: of moles of solute/ Mass of solvent(kg)  
=  $2/1.133$   
=  $1.765 \text{ molkg}^{-1}$

21. Moles of Mg =  $0.6/24 = 0.025$  mol

Moles of HCl = Molarity  $\times$  Volume  
=  $0.4 \text{ M} \times 0.1$   
= 0.04 mol



	Mg	HCl
As per eqn,	1	2
As per qsn,	0.025	?

No: of moles of HCl = 0.05 mol

HCl is the limiting reagent.

	HCl	H <sub>2</sub>
As per eqn,	2	1
As per qsn,	0.04	?

Moles of H<sub>2</sub> = 0.02 mol

Mass of HCl = 0.02 × 36.5  
= 0.73 g

22.

Moles of C = 49.48/12 = 4.12 mol

Moles of H = 5.19/1 = 5.19 mol

Moles of O = 16.48/16 = 1.03 mol

Moles of N = 28.85/14 = 2.06 mol

Empirical formula = C<sub>4</sub>H<sub>5</sub>N<sub>2</sub>O

Molecular formula = C<sub>8</sub>H<sub>10</sub>N<sub>4</sub>O<sub>2</sub>

23. a. Total mass of solution = 100 g

Mass of HCl = 40g

Moles of HCl = 40/36.5 = 1.09 mol

Density of solution = m/v

1.2 = 100/ V

Vol of solution = 83.3 ml

Molarity = moles of HCl / Vol of solution in L

= 1.09/0.0833

= 13.08 M

b.

pV = nRT

p = 760 mm Hg = 1 atm

V = 37.2 cm<sup>3</sup> = 0.0372 L

R = 0.082 atm LK<sup>-1</sup>mol<sup>-1</sup>

T = 378 K

n = 0.0012 mol

n = m / MM

0.0012 = 0.12 / MM

Molar mass = 100 g mol<sup>-1</sup>

Molar mass / Empirical formula mass = 100/ 49.5 = 2

Molecular formula = C<sub>2</sub>H<sub>4</sub>Cl<sub>2</sub>

c. Equal volumes of all gases at the same temperature and pressure should contain equal number of molecules.

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