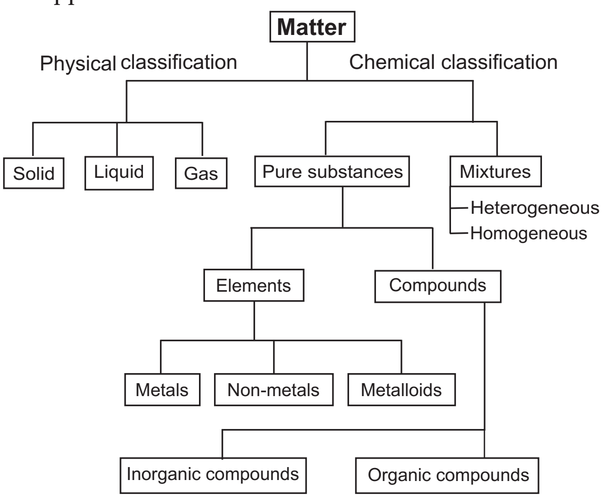
01

Some Basic Concepts of Chemistry

Quick Revision

1. All those things that have mass and a physical appearance can be considered as matter.



(i) **Mixture** is formed by mixing two or more substances together in any proportion. It can be **homogeneous** (uniform composition throughout) or **heterogeneous** (different composition throughout).

(ii) **Pure substances** have fixed composition and non-variable properties. An element is a substance that contains only one type of atoms, whereas a compound is formed when atoms of different elements combine in a fixed ratio.

2. **Some Physical Quantities**

(i) **Mass and weight** Mass (m) is the amount of matter present in a substance. Weight (w) is the force exerted by gravity on an object.

$$w = m \times g$$

where, m = mass, g = gravity.

(ii) **Volume** The space occupied by matter (usually by liquid or a gas) is called its volume.

$$\text{Volume} = (\text{length})^3 = \text{m}^3$$

$$1\text{m}^3 = (100\text{ cm})^3 = 10^6\text{cm}^3$$

$$= 10^3\text{ dm}^3 = 10^3\text{ L}$$

(iii) **Density** It is defined as the amount or mass per unit volume and has units kg m^{-3} or g cm^{-3}.

$$\text{Density} = \text{Mass/Volume}$$

(iv) **Temperature** It is defined as the degree of hotness or coldness. Its unit are °C, °F and K but its SI unit is K.

$$^\circ\text{C} = \frac{5}{9}(^\circ\text{F}) - 32$$

or $$^\circ\text{F} = \frac{9}{5}(^\circ\text{C}) + 32$$

$$^\circ\text{C} = \text{K} - 273.15$$

3. **Significant Figures**

These are the total number of digits in a number including the last digit whose value is uncertain.

Rules for counting the number of significant figures are as follows :

(i) All digits are significant except zero at the beginning of the number.

(ii) The zeroes to the left of the first non-zero digit in a number are not significant.

(iii) The zeroes to the right of the decimal point are significant.

(iv) The above rules propose that, the numbers are expressed in scientific notation. In this term, every number is written as $N \times 10^n$.

where,

N = a number with a single non-zero digit to the left of the decimal point

n = an integer

Significant figures in operational calculation are as follows :

- The result of an addition or subtraction should be reported to the same number of decimal places as that of the term with least number of decimal places.
- The result of a multiplication or division should be reported to the same number of significant figures as is possessed by the least precise term used in the calculation.
- If a calculation involves a number of steps, the result should contain the same number of significant figures as that of the least precise number involved other than the exact number.

4. **Accuracy and Precision**

(i) **Accuracy** is the agreement of a particular value to the true value of the result.

Accuracy = Mean value – True value

(ii) **Precision** refers to the closeness of various measurements for the same quantity.

Precision = Individual value – Arithmetic mean value

5. **Dimensional Analysis**

In calculations, sometimes it becomes necessary to convert units from one system to another. This is achieved by factor label method or unit factor method (CF) or dimensional analysis.

Information sought = Information given × CF

6. **Different Masses, Mole Concept and Formula of Compounds**

(i) Atomic mass

$$= \frac{\text{Mass of an atom}}{(1/12) \times \text{Mass of a carbon atom } (^{12}\text{C})}$$

(ii) Average atomic mass

$$= \frac{\Sigma\, p_i A_i}{100}$$

$$= \frac{p_1 A_1 + p_2 A_2 + \ldots}{100}$$

where, p_i is the percentage abundance of isotope having atomic mass A_i.

(iii) Gram atomic mass = Atomic mass expressed in gram = gram atom

(iv) Molecular mass is defined as the sum of atomic masses of all the elements present in a molecule.

(v) Gram molecular mass or gram molecule

= Molecular mass expressed in gram

(vi) Formula mass for an ionic compound

= number of cations × its atomic mass + number of anions × its atomic mass

(vii) Relation between molecular mass and vapour density of a gas

Molecular mass = 2 × vapour density

(viii) Mole concept and molar masses

- Number of moles of atoms
  $$= \frac{\text{Given mass of element}}{\text{Atomic mass of element}}$$
- Number of moles of molecules
  $$= \frac{\text{Given mass of molecule}}{\text{Molecular mass}}$$
- Number of moles of gases
  $$= \frac{\text{Volume of the gas (STP)}}{22.4 \text{ L}}$$
- 1 mole $= 6.022 \times 10^{23}$ particles
  = Gram atomic/molecular mass
- Number of molecules
  = number of moles × N_A,
  where, N_A = Avogadro's number $= 6.022 \times 10^{23}$
- Number of atoms = number of molecules × atomicity (or number of atoms in molecule of an element of a compound)

7. **Percentage Composition**

Mass % of an element

$$= \frac{\text{Mass of element in 1 mole of compound} \times 100}{\text{Mass of 1 mole of compound}}$$

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

Molecular formula = $n \times$ empirical formula

8. **Empirical and Molecular Formula**

An **empirical formula** represents the simplest whole number ratio of various atoms present in a compound, whereas the **molecular formula** shows the exact number of different types of atoms present in the molecule of a compound.

Short Trick to Find Empirical and Molecular Formula

***Step* 1** Divide percentage composition by atomic mass to obtain atomic ratio.

***Step* 2** Divide atomic ratio by minimum value of atomic ratio to obtain simplest ratio.

***Step* 3** Multiply simplest ratio by integer to obtain simplest whole number ratio.

***Step* 4** Write symbols of various elements present with their respective whole number ratio as a subscript to the lower hand corner of symbol to obtain empirical formula

***Step* 5** Multiply empirical formula by n to obtain molecular formula

$$\left(n = \frac{\text{Molecular mass}}{\text{Empirical formula mass}}\right)$$

9. **Stoichiometry and Stoichiometric Calculation**

The calculations involving the amount of reactants and products in a given chemical reaction is called the stoichiometry.

The number before the formula unit or molecules used to balance the equation are called stoichiometric coefficients.

- In the balanced reaction,

$$CH_4(g) + 2O_2(g) \longrightarrow CO_2(g) + 2H_2O(g),$$

the coefficients 2 for O_2 and H_2O are called **stoichiometric coefficients.**

Similarly, for CH_4 and CO_2, stoichiometric coefficients are 1 only.

- According to the above chemical reaction,
  (i) One mole of $CH_4(g)$ reacts with two moles of $O_2(g)$ to give one mole of $CO_2(g)$ and two moles of $H_2O(g)$.
  (ii) One molecule of $CH_4(g)$ reacts with 2 molecules of $O_2(g)$ to give one molecule of $CO_2(g)$ and 2 molecules of $H_2O(g)$.
  (iii) 22.7 L of $CH_4(g)$ reacts with 45.4 L of $O_2(g)$ to give 22.7 L of $CO_2(g)$ and 45.4 L of $H_2O(g)$.
  (iv) 16 g of $CH_4(g)$ reacts with 2×32 g of $O_2(g)$ to give 44g of CO_2 and 2×18 g of $H_2O(g)$.

Limiting reagent The reactant which consumed completely in a reaction is called limiting reactant / reagent. It decides the amount of other reactants reacted or the amount of products formed.

10. **Concentration Terms of Solutions**

The concentration of the solution is usually expressed in the following ways :

(i) **Mass per cent**

$$\text{Mass per cent} = \frac{\text{Mass of solute}}{\text{Mass of solution}} \times 100$$

(ii) **Volume percentage** Volume per cent of A

$$= \frac{\text{Volume of } A}{\text{Volume of } A + \text{Volume of } B} \times 100$$

(iii) **Part per million,** (ppm)

$$\text{ppm of } A = \frac{\text{Mass of compound } A}{\text{Total mass of solution}} \times 10^6$$

(iv) **Mole fraction** In case of a solution of two components A and B, mole fraction of A,

$$\chi_A = \frac{\text{Number of moles of } A}{\text{Total number of moles of solution}} = \frac{n_A}{n_A + n_B}$$

(where, n_A and n_B are the moles of A and B respectively).

Also, remember that $\chi_A + \chi_B = 1$

(v) **Molarity** (M) It is defined as the number of moles of the solute present in 1L of the solution. Thus, molarity

$$(M) = \frac{\text{Number of moles of solute}}{\text{Volume of solution (in L)}}$$

or $$M = \frac{\text{Mass of solute} \times 1000}{\text{Molar mass of solute} \times V \text{ (in mL)}}$$

The units of molarity is mol L^{-1} or mol dm^{-3}.

$$M = \frac{\text{\% by weight} \times \text{specific gravity} \times 10}{\text{Molar mass}}$$

In case of dilution, $M_1V_1 = M_2V_2$

where, M_1 and V_1 are the molarity and volume before dilution and M_2 and V_2 are the molarity and volume after dilution respectively.

(vi) **Molality** (m) It is defined as the number of moles of solute present in 1 kg of solvent. It is denoted by m.

Thus, molality

$$(m) = \frac{\text{Number of moles of solute}}{\text{Mass of solvent (in kg)}}$$

or $$m = \frac{\text{Mass of solute} \times 1000}{\text{Molar mass of solute} \times \text{Mass of solvent (in g)}}$$

The SI unit for molarity is mol kg^{-1}.

Objective Questions

Multiple Choose Questions

1. If measured temperature on Fahrenheit scale is 200°F then the reading on Celsius scale will be ....

(a) 40°C (b) 94°C
(c) 93.3°C (d) 30°C

2. Which one of the following data has only four significant figures?

(a) 6.023×10^{23} (b) 285 cm
(c) 0.0025 L (d) 0.200 g

3. The number of significant figures in 10.3406 g is ......

(a) 2 (b) 3 (c) 1 (d) 6

4. The result of which of the following has/have least significant figure(s)?

(a) $\frac{0.02856 \times 298.15 \times 0.112}{0.5785}$

(b) 5×5.364

(c) $0.0125 + 0.7864 + 0.0215$

(d) All have same number of significant figures.

5. A refers to the closeness of various measurements for the same quantity. B is the agreement of a particular value to the true value of the result. A and B respectively are

(a) $A \rightarrow$ significant figures, $B \rightarrow$ accuracy
(b) $A \rightarrow$ accuracy, $B \rightarrow$ precision
(c) $A \rightarrow$ precision, $B \rightarrow$ accuracy
(d) $A \rightarrow$ significant figures, $B \rightarrow$ precision

6. The least count of an instrument is 0.01 cm. Taking all precautions, the most possible error in the measurement can be ....

(a) 0.005 cm (b) 0.01 cm
(c) 0.0001 cm (d) 0.1 cm

7. Given that, the true value for a result is 2.00 g. Three students A, B and C take two measurements and report the result, data to illustrate precision and accuracy as given below.

Student	Measurement (in g)		
	1	2	Average (in g)
Student A	1.95	1.93	1.940
Student B	1.94	2.05	1.995
Student C	2.01	1.99	2.000

Which of the following students got the values which are both precise and accurate?

(a) Student A (b) Student B
(c) Student C (d) None of these

8. Which of the following statements about the molecular mass is correct?

(a) Molecular formula shows the exact number of different types of atoms present in a molecule.
(b) Molecular formula can be obtained from empirical formula if molar mass is known.
(c) Percentage composition of a compound can be calculated from its molecular formula.
(d) All the above statements are correct.

9. The weight of one molecule of a compound $C_{60}H_{122}$ is ....

(a) 1.3×10^{-20} g (b) 5.01×10^{-21} g
(c) 3.72×10^{12} g (d) 1.4×10^{-21} g

10. In the standardisation of $Na_2S_2O_3$ using $K_2Cr_2O_7$ by iodometry, the equivalent weight of $K_2Cr_2O_7$ is

(a) $\frac{\text{molecular weight}}{2}$
(b) $\frac{\text{molecular weight}}{6}$
(c) $\frac{\text{molecular weight}}{3}$
(d) same as molecular weight

11. One mole of any substance contains 6.022×10^{23} atoms/molecules. What will be number of molecules of H_2SO_4 present in 100 mL of 0.02 M H_2SO_4 solution? ***(NCERT Exemplar)***

(a) 12.044×10^{20} molecules
(b) 6.022×10^{23} molecules
(c) 1×10^{23} molecules
(d) 12.044×10^{23} molecules

12. The number of molecules in 18 mg of water in terms of Avogadro number, N_A is ....

(a) $10^{-3}N_A$ (b) $10^{-2}N_A$ (c) $10^{-1}N_A$ (d) $10\,N_A$

13. If 1 mL of water contains 20 drops then number of molecules in one drop of water is ...... molecules

(a) 6.023×10^{23} (b) 1.376×10^{26}
(c) 1.344×10^{18} (d) 4.346×10^{20}

14. In which case is the number of molecules of water maximum ?

(a) 0.00224 L of water vapours at 1 atm and 273 K
(b) 0.18 g of water
(c) 18 mL of water
(d) 10^{-3} mole of water

15. Match the following Column I with Column II and choose the correct codes from the option given below.

Column I	Column II
A. 46 g of Na	1. 0.01 mol
B. 6.022×10^{23} molecules of H_2O	2. 2 mol
C. 0.224 L of O_2 at STP	3. 1 mol
D. 84 g of N_2	4. 6.022×10^{23} atoms/molecules
E. 1 mole of any gas	5. 3 mol

Codes

	A	B	C	D	E
(a)	2	3	1	5	4
(b)	1	2	3	4	5
(c)	4	2	1	3	4
(d)	5	4	3	1	2

16. The mass per cent of different elements present in sodium sulphate, (i.e. sodium, sulphur and oxygen) respectively are ***(NCERT Exemplar)***

(a) 32.37 ; 45.06 and 22.57
(b) 22.57 ; 32.37 and 45.06
(c) 45.06 ; 32.37 and 40.06
(d) 32.37 ; 22.57 and 45.06

17. What is the mass per cent of carbon in carbon dioxide?

(a) 0.034% (b) 27.27%
(c) 3.4% (d) 28.7%

18. The empirical formula and molecular mass of a compound are CH_2O and 180 g respectively. What will the molecular formula of the compound?

(a) $C_9H_{18}O_9$ (b) CH_2O
(c) $C_6H_{12}O_6$ (d) $C_2H_4O_2$

19. Find empirical formula of the compound if $M = 68\%$ (atomic mass = 34) and remaining 32 % oxygen.

(a) MO (b) M_2O
(c) MO_2 (d) M_2O_3

20. An organic compound on analysis was found to contain 10.06% carbon, 0.84% hydrogen and 89.10% chlorine. What will be the empirical formula of the substance?

(a) CH_2Cl_2 (b) $CHCl_3$
(c) CCl_4 (d) CH_3Cl

21. Out of two oxides of iron, the first contained 22% and the second contained 30% of oxygen by weight. The ratio of weights of iron in the two oxides that combine with the same weight of oxygen is ....

(a) 3:2 (b) 2:1
(c) 1:2 (d) 1:1

22. Stoichiometric ratio of sodium dihydrogen orthophosphate and sodium hydrogen orthophosphate required for the synthesis of $Na_5P_3O_{10}$ is

(a) 1.5 : 3 (b) 3 : 1.5
(c) 1 : 1 (d) 2 : 3

23. What is the stoichiometric coefficient of Ca in the reaction?

$$Ca + Al^{3+} \longrightarrow Ca^{2+} + Al$$

(a) 2 (b) 1 (c) 3 (d) 4

24. In the reaction of oxalate with permanganate in acidic medium, the number of electrons involved in producing one molecule of CO_2 is ....

(a) 2 (b) 5 (c) 1 (d) 10

25. 1.0 g of magnesium is burnt with 0.56 g O_2 in a closed vessel. Which reactant is left in excess and how much? (Atomic weight, Mg = 24, O = 16)

(a) Mg, 0.16 g (b) O_2, 0.16 g
(c) Mg, 0.44 g (d) O_2, 0.28 g

26. For a reaction,

$N_2(g) + 3H_2(g) \longrightarrow 2NH_3(g)$, identify dihydrogen (H_2) as a limiting reagent in the following reaction mixtures.

(a) 56 g of N_2 + 10 g of H_2
(b) 35 g of N_2 + 8 g of H_2
(c) 14 g of N_2 + 4 g of H_2
(d) 28 g of N_2 + 6 g of H_2

27. If 0.5 mole of $BaCl_2$ is mixed with 0.20 mole of Na_3PO_4, the maximum number of $Ba_3(PO_4)_2$ that can be formed is ....

(a) 0.70 (b) 0.50 (c) 0.20 (d) 0.10

28. What volume of oxygen gas (O_2) measured at 0°C and 1 atm, is needed to burn completely 1 L of propane gas (C_3H_8) measured under the same conditions?

(a) 7 L (b) 6 L (c) 5 L (d) 10 L

29. How many moles of lead (II) chloride will be formed from a reaction between 6.5 g of PbO and 3.2 g of HCl?

(a) 0.044 (b) 0.333
(c) 0.011 (d) 0.029

30. 1 g of a carbonate (M_2CO_3) on treatment with excess HCl produces 0.01186 mole of CO_2. The molar mass of M_2CO_3 in g mol^{-1} is ....

(a) 1186 (b) 84.3 (c) 118.6 (d) 11.86

31. How many grams of concentrated nitric acid solution should be used to prepare 250 mL of 2.0 M HNO_3? The concentrated acid is 70% HNO_3.

(a) 45.0 g conc. HNO_3 (b) 90.0 g conc. HNO_3
(c) 70.0 g conc. HNO_3 (d) 54.0 g conc. HNO_3

32. The mass of potassium dichromate crystals required to oxidise 750 cm^3 of 0.6 M Mohr's salt solution is (Given, molar mass : potassium dichromate = 294, Mohr's salt = 392)

(a) 0.49 g (b) 0.45 g
(c) 22.05 g (d) 2.2 g

33. The normality of 10% (w/V) of acetic acid is ......

(a) 1 N (b) 1.3 N
(c) 1.7 N (d) 1.9 N

34. If 500 mL of a 5 M solution is diluted to 1500 mL, what will be the molarity of the solution obtained? ***(NCERT Exemplar)***

(a) 1.5 M (b) 1.66 M
(c) 0.017 M (d) 1.59 M

35. The number of molecules in 100 mL of 0.02 N H_2SO_4 is ......

(a) 6.023×10^{22} (b) 6.023×10^{21}
(c) 6.023×10^{20} (d) 6.023×10^{18}

36. The molarity of one litre solution of 22.2 g of $CaCl_2$ will be ......

(a) 0.4 M (b) 0.2 M
(c) 0.8 M (d) 0.6 M

37. Dissolving 120 g of urea (mol. wt. 60) in 1000 g of water gave a solution of density 1.15 g/mL. The molarity of the solution is ......

(a) 1.78 M (b) 2.00 M
(c) 2.05 M (d) 2.22 M

38. What is the concentration of sugar $(C_{12}H_{22}O_{11})$ in mol L^{-1} if its 20 g are dissolved in enough water to make a final volume up to 2 L in mol L^{-1}?

(a) 0.0592 (b) 0.0292
(c) 0.0375 (d) 0.0711

39. What will be the molality of the solution containing 18.25 g of HCl gas in 500 g of water? ***(NCERT Exemplar)***

(a) 0.1 m (b) 1 M
(c) 0.5 m (d) 1m

40. The density of 2 M aqueous solution of NaOH is 1.28 g/cm^3. The molality of the solution is ......
[Given that, molecular mass of NaOH = 40 g mol^{-1}]

(a) 1.20 m (b) 1.56 m (c) 1.67 m (d) 1.32 m

41. A sample of nitric acid is 69% by mass and it has a concentration of 15.44 moles per litre. Its density is ......

(a) 1.86 g/cc (b) 1.41 g/cc
(c) 2.60 g/cc (d) 1.02 g/cc

42. Mole fraction of the solute in a 1.00 molar aqueous solution is ......

(a) 0.0177 (b) 0.0344
(c) 1.7700 (d) 0.1770

43. 8 g of NaOH is dissolved in 18 g of H_2O. Mole fraction of NaOH in solution and molality (in mol kg^{-1}) of the solution respectively are ......

(a) 0.2, 11.11 (b) 0.167, 22.20
(c) 0.2, 22.20 (d) 0.167, 11.11

44. Match the items of Column I with Column II and choose the correct codes from the options given below.

Column I	Column II
A. Mole fraction	1. $M_2 \times V_2$
B. Molarity	2. The solution of higher concentration.
C. Molality	3. It is defined as the number of moles of solute present in 1 kg of solvent.
D. $M_1 \times V_1$	4. It is the ratio of number of moles of a partial component to the total number of moles of the solution.
E. Stock solution	5. It is defined as the number of moles of the solute in 1 L of the solution.

Codes

	A	B	C	D	E
(a)	1	2	3	4	5
(b)	4	5	3	1	2
(c)	1	2	5	4	3
(d)	3	2	1	4	5

45. Match the following physical quantities with their units and choose the correct codes from the options given below.

Column I (Physical quantity)	Column II (Unit)
A. Molarity	1. mol
B. Mole fraction	2. Unitless
C. Mole	3. mol L^{-1}
D. Molality	4. mol kg^{-1}

Codes

	A	B	C	D		A	B	C	D
(a)	3	2	1	4	(b)	2	1	4	3
(c)	3	2	1	3	(d)	1	2	4	3

Assertion-Reasoning MCQs

Directions In the following questions (Q.No. 46-60) a statement of Assertion followed by a statement of Reason is given. Choose the correct answer out of the following choices.

(a) Both Assertion and Reason are correct statements and Reason is the correct explanation of the Assertion.
(b) Both Assertion and Reason are correct statements, but Reason is not the correct explanation of the Assertion.
(c) Assertion is correct, but Reason is incorrect statement.
(d) Assertion is incorrect but Reason is correct statement.

46. **Assertion** Significant figures for 0.200 is 3 where as for 200 it is 1.

Reason Zero at the end or right of a number are significant provided they are not on the right side of the decimal point. ***(NCERT Exemplar)***

47. **Assertion** A number 138.42 can be written as 1.3842×10^2 in scientific notation.

Reason In scientific notation, a number is generally expressed in the form of $N \times 10^n$, where N is a number between 1.00 ... and 9.999 ... and n is an exponent.

48. **Assertion** 1.231 has three significant figures.

Reason All numbers right to the decimal point are significant.

49. **Assertion** Equivalent weight of Cu in CuO is 31.8 and in Cu_2O is 63.6.

Reason Equivalent weight of an element

$$= \frac{\text{Atomic weight of the element}}{\text{Valency of the element}}$$

50. **Assertion** The empirical mass of ethene is half of its molecular mass.

Reason The empirical formula represents the simplest whole number ratio of various atoms present in a compound. ***(NCERT Exemplar)***

51. **Assertion** Molar volume of gases change considerably with temperature and pressure.

Reason Molar volume of a substance is the volume occupied by 1 mole of that substance.

52. **Assertion** The balancing of chemical equations is based on law of conservation of mass.

Reason Total mass of reactants is equal to total mass of products.

53. **Assertion** One atomic mass unit is defined as one twelfth of the mass of one carbon-12 atom.

Reason Carbon-12 isotope is the most abundant isotope of carbon and has been chosen as standard. ***(NCERT Exemplar)***

54. **Assertion** Atomicity of oxygen is 2.

Reason 1 mole of an element contains 6.023×10^{23} atoms.

55. **Assertion** Number of g-molecules of SO_2Cl_2 in 13.5 g of sulphuryl chloride is 0.2.

Reason Gram-molecules is equal to those molecules which are expressed in gram.

56. **Assertion** One mole of SO_2 contains equal the number of molecules present in one mole of O_2.

Reason Molecular weight of SO_2 is half to that of O_2.

57. **Assertion** Molecular weight of a compound is 44 if its vapour density is 22.

Reason Vapour density × 2 = Molecular weight.

58. **Assertion** Combustion of 16 g of methane gives 18 g of water.

Reason In the combustion of methane, water is one of the products.

(NCERT Exemplar)

59. **Assertion** A reactant that is entirety consumed when a reaction goes to completion is known as limiting reaction.

Reason The amount of limiting reactant limits the amount of product formed.

60. **Assertion** Molarity of a solution represents its concentration.

Reason Molarity is the number of moles of solute per litre of solution.

Case Based MCQs

61. Read the passage given below and answer the following questions :

The identity of a substance is defined not only by the types of atoms or ions it contains, but by the quantity of each type of atom or ion. The experimental approach required the introduction of a new unit for amount of substances, the mole, which remains indispensable in modern chemical science. The mole is an amount unit similar to familiar units like pair, dozen, gross, etc. It provides a specific measure of the number of atoms or molecules in a bulk sample of matter.

A **mole** is defined as the amount of substance containing the same number of discrete entities (atoms, molecules, ions, etc.) as the number of atoms in a sample of pure ^{12}C weighing exactly 12g. One Latin connotation for the word "mole" is "large mass" or "bulk," which is consistent with its use as the name for this unit.

The mole provides a link between an easily measured macroscopic property, bulk mass, and an extremely important fundamental property, number of atoms, molecules and so forth.

The number of entities composing a mole has been experimentally determined to be 6.02214179 × 10236.02214179 × 1023, a fundamental constant named Avogadro's number (N_A) or the Avogadro constant in honor of Italian scientist Amedeo Avogadro. This constant is properly reported with an explicit unit of "per mole," a conveniently rounded version being 6.022×1023/mol 6.022×1023/mol.

Consistent with its definition as an amount unit, 1 mole of any element contains the same number of atoms as 1 mole of any other element. The masses of 1 mole of different elements, however, are different, since the masses of the individual atoms are drastically different.

The molar mass of an element (or compound) is the mass in grams of 1 mole of that substance, a property expressed in units of grams per mole (g/mol).

The following questions (i-iv) are multiple choice questions. Choose the most appropriate answer :

(i) A sample of copper sulphate pentahydrate contains 8.64 g of oxygen. How many grams of Cu is present in the sample ?

(a) 0.952g (b) 3.816g
(c) 3.782g (d) 8.64g

(ii) A gas mixture contains 50% helium and 50% methane by volume. What is the per cent by weight of methane in the mixture?

(a) 19.97% (b) 20.05%
(c) 50% (d) 80.03%

(iii) The mass of oxygen gas which occupies 5.6 litres at STP could be

(a) gram atomic mass of oxygen
(b) one fourth of the gram atomic mass of oxygen
(c) double the gram atomic mass of oxygen
(d) half of the gram atomic mass of oxygen

(iv) What is the mass of one molecule of yellow phosphorus? (Atomic mass of phosphorus = 30)

(a) 1.993×10^{-22} mg
(b) 1.993×10^{-19} mg
(c) 4.983×10^{-20} mg
(d) 4.983×10^{-23} mg

Or

The number of moles of oxygen in 1L of air containing 21% oxygen by volume, in standard conditions is

(a) 0.186 mol (b) 0.21 mol
(c) 2.10 mol (d) 0.0093 mol

62. Read the passage given below and answer the following questions :

A chemical reaction is a change in which one or more substance(s) react(s) to form new substance(s) with entirely different properties.

A chemical equation is a brief representation of a chemical reaction in terms of symbols and formulae of substances involved in it, e.g. the reaction of silver nitrate with sodium chloride to give silver chloride and sodium nitrate can be represented as

$$\underbrace{AgNO_3 + NaCl}_{\text{Reactants}} \longrightarrow \underbrace{AgCl + NaNO_3}_{\text{Products}}$$

The substances which react among themselves to bring about the chemical changes are known as reactants whereas, the substances which are produced as a result of the chemical change, are known as products.

Reactants and products of a chemical equation are separated by arrow pointing towards the products.

Quantitative information conveyed by a chemical equation is as follows :

- The relative number of reactant and product species (atoms or molecules) taking part in the reaction.
- The relative number of moles of the reactants and products.
- The relative masses of the reactants and products.
- The relative volumes of gaseous reactants and products.

The reactant which is present in the lesser amount and gets consumed after sometime, i.e. which limits the amount of product formed is called the limiting reagent.

The reactant other than the limiting reagent, which is in somewhat excess is called the excess reagent. The remaining amount of excess reagent is calculated by subtracting the available amount of limiting reagent from the amount of the excess reagent.

Remember that in stoichiometric calculations, it is very important to choose the limiting reagent.

The following questions (i-iv) are multiple choice questions. Choose the most appropriate answer :

(i) What will be the volume of the mixture after the reaction?

$$\underset{1\ L}{NH_3(g)} + \underset{1.5\ L}{HCl(g)} \longrightarrow NH_4Cl(s)$$

(a) 1.5 L (b) 0.5 L
(c) 1 L (d) 0 L

(ii) For the formation of 3.65 g hydrogen chloride gas, what volume of hydrogen gas and chlorine gas are required at NTP conditions?

(a) 1.12 L, 1.12 L

(b) 1.12 L, 2.24 L

(c) 3.65 L, 1.83 L

(d) 1 L, 1 L

(iii) A gas mixture contains 50% He and 50% CH_4 by volume. What is the percentage by weight of methane in the mixture ?

(a) 19.97% (b) 20.05%

(c) 50 (d) 80.03%

(iv) $AgNO_3$ will react with 5.85 g NaCl to produce 14.35 g of AgCl and 8.5 g of $NaNO_3$. Than mass of $AgNO_3$ will be …… .

(a) 1.7 g (b) 17.0 g

(c) 170 g (d) 0.17 g

Or

The percentage of nitrogen in urea is

(a) 46% (b) 85%

(c) 18% (d) 28%

63. Read the passage given below and answer the following questions :

Stoichiometry is a section of chemistry that involves a calculation based on chemical equations. Chemical equations are governed by laws of chemical combination.

The mass of reactants is equal to the mass of products. The compound obtained from different methods contains the same elements in the fixed ratio by mass. A mole is a counting unit, equal to 6.022×10^{23} particles.

One mole is also equal to molar mass expressed in grams.

One mole of every gas at STP has a volume equal to 22.4 L.

The reacting species which are consumed in the reaction completely is called limiting reagent which decides the amount of products formed.

In these questions (i-iv) a statement of Assertion followed by a statement of Reason is given. Choose the correct answer out of the following choices :

(a) Assertion and Reason both are correct statements and Reason is correct explanation for Assertion.

(b) Assertion and Reason both are correct statements but Reason is not correct explanation for Assertion.

(c) Assertion is correct statement but Reason is incorrect statement.

(d) Assertion is incorrect statement but Reason is correct statement.

(i) **Assertion** 22.4 L of N_2 at NTP and 5.6 L of O_2 at NTP contain equal number of molecules.

Reason Under similar conditions of temperature and pressure, all gases contain equal number of molecules.

(ii) **Assertion** A reactant that is entirely consumed when a reaction goes to completion is known as limiting reagent.

Reason The amount of limiting reactant limits the amount of product formed.

(iii) **Assertion** Both 44 g CO_2 and 16 g CH_4 have same number of carbon atoms.

Reason Both contain 1 g atom of carbon which contains 6.023×10^{23} carbon atoms.

(iv) **Assertion** As mole is the basic chemical unit, the concentration of the dissolved solute is usually specified in terms of number of moles of solute.

Reason The total number of molecules of reactants involved in a balanced chemical equation is known as molecularity of the reaction.

Or

Assertion One mole of NaCl contains 6.023×10^{23} molecules of sodium chloride.

Reason 58.5 g of NaCl also contains 6.023×10^{23} molecules of NaCl.

64. Read the passage given below and answer the following questions :

Most of the reactions occuring in the laboratories are carried out in solutions. In solutions, generally two components are present. The one which is user in amount is called the solute and the other one which is in higher amount is called the solvent. The amount of solute present in a given quantity of solvent or solution is expressed in term of concentration.

The concentration of the solution is expressed in many ways, i.e. in mass percent, volume percent, parts per million, mole fraction, molarity, molality and normality.

In these questions (i-iv) a statement of Assertion followed by a statement of Reason is given. Choose the correct answer out of the following choices :

(a) Assertion and Reason both are correct statements and Reason is correct explanation for Assertion.

(b) Assertion and Reason both are correct statements but Reason is not correct explanation for Assertion.

(c) Assertion is correct statement but Reason is incorrect statement.

(d) Assertion is incorrect statement but Reason is correct statement.

(i) **Assertion** The mass percentage of an element is used to determine percentage composition of each element in a compound.

Reason Mass percentage depends up the molar mass of the compound.

(ii) **Assertion** The sum of mole fraction of all the components of a solution is unity.

Reason Mole fraction is a temperature dependent mode of concentration.

(iii) **Assertion** Molarity of a solution represents its concentration.

Reason Molarity is the number of moles of solute per litre of solution.

(iv) **Assertion** The molality of solution does not change with change in temperature.

Reason Molality depend on the mass of the solvent.

Or

Assertion Molarity of solution independent of temperature.

Reason Volume of a solution is temperature dependent, i.e. it changes with change in temperature.

ANSWERS

Multiple Choice Questions

1. (c)	*2. (a)*	*3. (d)*	*4. (a)*	*5. (c)*	*6. (b)*	*7. (c)*	*8. (d)*	*9. (d)*	*10. (b)*
11. (a)	*12. (a)*	*13. (c)*	*14. (c)*	*15. (a)*	*16. (d)*	*17. (b)*	*18. (c)*	*19. (a)*	*20. (b)*
21. (a)	*22. (b)*	*23. (c)*	*24. (c)*	*25. (a)*	*26. (a)*	*27. (d)*	*28. (c)*	*29. (d)*	*30. (b)*
31. (a)	*32. (c)*	*33. (c)*	*34. (b)*	*35. (c)*	*36. (b)*	*37. (c)*	*38. (b)*	*39. (d)*	*40. (c)*
41. (b)	*42. (a)*	*43. (d)*	*44. (b)*	*45. (a)*					

Assertion-Reasoning MCQs

46. (c)	*47. (a)*	*48. (d)*	*49. (a)*	*50. (a)*	*51. (b)*	*52. (a)*	*53. (b)*	*54. (b)*	*55. (d)*
56. (c)	*57. (a)*	*58. (d)*	*59. (a)*	*60. (a)*					

Case Based MCQs

61. (i)-(b), (ii)-(d), (iii)-(d), (iv)-(b) or-(d)

62. (i)-(b), (ii)-(a), (iii)-(d), (iv)-(b) or-(a)

63. (i)-(a), (ii)-(a), (iii)-(a), (iv)-(b) or-(b)

64. (i)-(b), (ii)-(c), (iii)-(a), (iv)-(a) or-(d)

EXPLANATIONS

1.
$$F = \frac{9}{5} t^\circ C + 32$$
$$(200 - 32) = \frac{9}{5} t^\circ C$$
$$\Rightarrow \quad \frac{9}{5} t^\circ C = 168$$
$$t^\circ C = \frac{168 \times 5}{9} = 93.3^\circ C$$

2. 6.023×10^{23} has four significant figures. The total number of digits in a number including the last digit whose value is uncertain is called the number of significant figures.

3. All non-zero digits are significant. Hence, there are 6 significant figures in 10.3406 g.

4. The result of $\frac{0.02856 \times 298.15 \times 0.112}{0.5785}$ has least significant figures.

(i) In multiplication and division, the least precise term 0.112 has 3 significant figures. Hence, the answer should not have more than 3 significant figures.

(ii) In multiplication, 5 is the exact number and the other number has 4 significant figures. Hence, the answer should have 4 significant figures.

(iii) In addition, the answer cannot have more digits to the decimal point than either of the original members. Hence, the answer should have 4 significant figures.

5. Precision refers to the closeness of various measurements for the same quantity. Accuracy is the agreement of a particular value to the true value of the result.
Thus, *A* and *B* are precision and accuracy respectively.

6. As we know that, least count of an instrument is equal to the most possible error of the instrument, hence most possible error of the instrument will be 0.01 cm.

7. Given that, the true value for a result is 2.00 g and student '*A*' takes two measurements and report the result as 1.95 g and 1.93 g. The values are precise as they are close to each other but are not accurate.

Another student (B) repeats the experiment and obtains 1.94 g and 2.05 g as the results for two measurements. These observations are neither precise nor accurate.

The third student (C) repeats these measurements and reports 2.01 g and 1.99 g as the result, these values are both precise and accurate.

8. All the given statements are correct about molecular mass.

9. The molecular weight of
$$C_{60}H_{122} = (60 \times 12) + (122 \times 1)$$
$$= 720 + 122 = 842 \text{ g/mol}$$
Weight of 6.023×10^{23} molecules of
$$C_{60}H_{122} = 842 \text{ g}$$
$\therefore$ Weight of 1 molecule of $C_{60}H_{122}$
$$= \frac{842}{6.023 \times 10^{23}} \text{ g} = 1.39 \times 10^{-21} \text{ g}$$
$$\approx 1.4 \times 10^{-21} \text{ g}$$
Thus, the weight of one molecule of $C_{60}H_{122}$ is 1.4×10^{-21} g.

10.
$$Cr_2O_7^{2-} + 14H^+ + 6e^- \longrightarrow 2Cr^{3+} + 7H_2O$$
$$6I^- \longrightarrow 3I_2 + 6e^-$$
$$2Na_2S_2O_3 + I_2 \longrightarrow Na_2S_4O_6 + 2NaI$$
In this reaction, equivalent weight of $K_2Cr_2O_7$
$$= \frac{\text{molecular weight}}{3 \times 2}$$
$$= \frac{\text{molecular weight}}{6}$$

11. One mole of any substance contains 6.022×10^{23} atoms/ molecules.
Hence, number of millimoles of
$$H_2SO_4 = \text{Molarity} \times \text{Volume (in mL)}$$
$$= 0.02 \times 100 = 2 \times 10^{-3} \text{ mol}$$
Number of molecules = number of moles $\times N_A$
$$= 2 \times 10^{-3} \times 6.022 \times 10^{23}$$
$$= 12.044 \times 10^{20} \text{ molecules}$$

12. In 18 g of water, number of H_2O molecules is N_A.
So, in 18 mg of water, number of H_2O molecules would be $= N_A \times \frac{18 \text{ mg}}{18 \times 10^3 \text{ mg}}$
$$= 10^{-3} \times N_A$$

13. $\because$ 22400 mL water contains water molecules
$$= 6.023 \times 10^{23} \text{ molecules}$$

$\therefore$ In 1 mL, the number of water molecules

$$= \frac{6.023 \times 10^{23}}{22400} \text{ molecules}$$

Since, 1 mL contains 20 drops.

Therefore, number of water molecules in 1 drop

$$= \frac{6.023 \times 10^{23}}{22400 \times 20}$$

$$= 1.344 \times 10^{18} \text{ molecules}$$

14. Number of molecules = mole × Avogadro's number (N_A)

The number of molecules of water in each of the given options is calculated as,

(a) $(V_{(H_2O)\,g})_{STP} = 0.00224\,L$

$$n_{H_2O} = \frac{V}{22.4\,L} = \frac{0.00224}{22.4} = 0.0001$$

$\therefore$ Number of molecules of water

$$= 0.0001 \times N_A$$

(b) 0.18 g of water

$$n_{H_2O} = \frac{w_{H_2O}}{M_{H_2O}} = \frac{0.18}{18} = 0.01$$

Number of molecules $= 0.01 \times N_A$

(c) 18 mL of water, number of moles (n_{H_2O})

$$= \frac{\text{mass of substance in g } (w_{H_2O})}{\text{molar mass in g mol}^{-1}\ (w_{H_2O})}$$

$w_{H_2O} = 18\,g/mol$

[$\because$ Density of water $(d_{H_2O}) = 1\ g\ L^{-1}$]

$$\therefore n_{H_2O} = \frac{18}{18} = 1$$

Number of molecules of water $= 1 \times N_A$

(d) $n_{H_2O} = 10^{-3}$

$\therefore$ Number of molecules of water

$$= 10^{-3} \times N_A$$

Hence, maximum number of molecules are present in 18 mL of water.

15. A → (2); B → (3); C → (1); D → (5); E → (4).

16. Mass per cent of an element

$$= \frac{\text{Mass of that element in the compound} \times 100}{\text{Molar mass of the compound}}$$

Molar mass of Na_2SO_4

$= (2 \times 22.99) + 32.06 + (4 \times 16.00)$

$= 142.04$ g

$$\text{Mass per cent of sodium} = \frac{45.98 \times 100}{142.04} = 32.37$$

$$\text{Mass per cent of sulphur} = \frac{32.06 \times 100}{142.04} = 22.57$$

$$\text{Mass per cent of oxygen} = \frac{64 \times 100}{142.04} = 45.06$$

17. Molecular mass of $CO_2 = 1 \times 12 + 2 \times 16 = 44$ g

1 g molecule of CO_2 contains 1 g atoms of carbon

$\because$ 44 g of CO_2 contain C = 12 g atoms of carbon

$$\therefore \quad \%\text{ of C in } CO_2 = \frac{12}{44} \times 100 = 27.27\%$$

Hence, the mass per cent of carbon in CO_2 is 27.27%.

18. Empirical formula mass $= CH_2O$

$= 12 + 2 \times 1 + 16 = 30$

Molecular mass = 180

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

$= 180/30 = 6$

$\therefore$ Molecular formula $= n \times$ empirical formula

$= 6 \times CH_2O = C_6H_{12}O_6$

19. Given, % of element $(M) = 68\%$

and of oxygen (O) = 32%

Atomic mass of $M = 34$

Atomic mass of O = 16

Thus, empirical formula of M_xO_y is

element ⟶ % of mass ⟶ moles (n)

M ⟶ 68 ⟶ 68/34 = 2

O ⟶ 32 ⟶ 32/16 = 2

Hence, empirical formula of given compound is M_2O_2 or MO.

Thus, option (a) is correct.

20.

Element	%	Atomic mass	Molar ratio	Simpler molar ratio
C	10.06%	12	$\frac{10.06}{12} = 0.84$	$\frac{0.84}{0.84} = 1$
H	0.84%	1	$\frac{0.84}{1} = 0.84$	$\frac{0.84}{0.84} = 1$
Cl	89.10%	35.5	$\frac{89.10}{35.5} = 2.5$	$\frac{2.5}{0.84} = 3$

Thus, the empirical formula of the substance is $CHCl_3$.

21. For first oxide,

Element	% amount	Atomic weight	Number of moles	Simple molar ratio
O	22	16	$\frac{22}{16}=1.375$	$\frac{1.375}{1.375}=1$
Fe	78	56	$\frac{78}{56}=1.392$	$\frac{1.392}{1.375}\approx 1$

$\therefore$ The formula of first oxide is FeO.

Similarly, for second oxide

Element	% amount	Atomic weight	Number of moles	Simple molar ratio
O	30	16	$\frac{30}{16}=1.875$	$\frac{1.875}{1.25}\approx 1.5$
Fe	70	56	$\frac{70}{56}=1.25$	$\frac{1.25}{1.25}=1$

$\therefore$ The formula of second oxide is Fe_2O_3.

Suppose in both the oxides, iron reacts with x g oxygen.

$\therefore$ Equivalent weight of Fe in FeO

$$=\frac{\text{weight of Fe (II)}}{\text{weight of oxygen}}\times 8$$

$$\frac{56}{2}=\frac{\text{weight of Fe (II)}}{x}\times 8 \quad \ldots\text{(i)}$$

Similarly, equivalent weight of Fe in Fe_2O_3

$$=\frac{\text{weight of Fe (III)}}{\text{weight of oxygen}}\times 8$$

$$\frac{56}{3}=\frac{\text{weight of Fe (III)}}{x}\times 8 \quad \ldots\text{(ii)}$$

From Eqs. (i) and (ii),

$$\frac{\text{weight of Fe (II)}}{\text{weight of Fe (III)}}=\frac{3}{2}$$

22. $2Na_2HPO_4 + NaH_2PO_4 + 2(NH_2)_2CO$
$\longrightarrow Na_5P_3O_{10} + 4NH_3 + 2CO_2$

Hence, the stoichiometric ratio of sodium dihydrogen orthophosphate and sodium hydrogen orthophosphate is 2 : 1 or 3 : 1.5.

23. $Ca \longrightarrow Ca^{2+} + 2e^-$ (Oxidation) ...(i)
$Al^{3+} + 3e^- \longrightarrow Al$ (Reduction) ...(ii)

Eq. (i) is multiplied by 3 and Eq. (ii) is multiplied by 2.

The two equations

$$3Ca \longrightarrow 3Ca^{2+} + 6e^-$$
$$2Al^{3+} + 6e^- \longrightarrow 2Al$$

Net reaction

$$3Ca + 2Al^{3+} \longrightarrow 3Ca^{2+} + 2Al$$

Therefore, the stoichiometric coefficient of Ca in the given reaction is 3.

24. Reaction of oxalate with permanganate in acidic medium.

$$5C_2O_4^{2-} + 2MnO_4 \longrightarrow 10CO_2 + 2Mn^{2+} + 8H_2O$$

No. of mol 5   10

$5C_2O_4^{2-}$ ions transfer $10e^-$ to produce 10 molecules of CO_2.

So, number of electrons involved in producing 10 molecules of CO_2 is 10. Thus, number of electrons involved in producing 1 molecule of CO_2 is 1.

25. The balanced chemical equation is

$$\underset{24\text{ g}}{Mg} + \underset{16\text{ g}}{\frac{1}{2}O_2} \longrightarrow \underset{40\text{ g}}{MgO}$$

From the above equation, it is clear that 24 g Mg reacts with 16 g O_2.

Thus, 1.0 g Mg reacts with, $\frac{16}{24}O_2 = 0.67\text{ g }O_2$

But only 0.56 g O_2 is available which is less than 0.67 g. Thus, O_2 is the limiting reagent.

Further, 16 g O_2 reacts with 24 g Mg.

$\therefore$ 0.56 g O_2 will react with Mg

$$=\frac{24}{16}\times 0.56 = 0.84\text{g}$$

$\therefore$ Amount of Mg left unreacted

$$= 1.0 - 0.84$$
$$= 0.16\text{ g Mg}$$

Hence, Mg is present in excess and 0.16 g Mg is left behind unreacted.

26. When 56 g of N_2 + 10 g of H_2 is taken as a combination then dihydrogen (H_2) act as a limiting reagent in the reaction.

$$\underset{\substack{2\times 14\text{ g}\\28\text{ g}}}{N_2(g)} + \underset{\substack{3\times 2\text{g}\\6\text{g}}}{3H_2(g)} \longrightarrow \underset{\substack{2(14+3)\\34\text{g}}}{2NH_3(g)} \quad \ldots\text{(I)}$$

28 g N_2 requires 6g H_2 gas.

56 g of N_2 requires $\frac{6\text{g}}{28\text{g}}\times 56\text{ g} = 12\text{g of }H_2$

12g of H_2 gas is required for 56g of N_2 gas but only 10g of H_2 gas is present in option (a).

Hence, H_2 gas is the limiting reagent.

In option (b), i.e. 35g of N_2 + 8g of H_2.

As 28g N_2 required 6g of H_2.

35g N_2 required $\frac{6g}{28g} \times 35\,g\,H_2 \Rightarrow$ 7.5g of H_2.

Hence, in option (b), H_2 does not act as limiting reagent.

Here, H_2 gas does not act as limiting reagent since 7.5g of H_2 gas is required for 35g of N_2 and 8g of H_2 is present in reaction mixture.

Mass of H_2 left unreacted $= 8 - 7.5$ g of H_2

$= 0.5$ g of H_2

Similarly, in option (c) and (d), H_2 does not act as limiting reagent.

For 14g of N_2 + 4g or H_2.

As we know, 28g of N_2 reacts with 6g of H_2.

14g of N_2 reacts with $\frac{6}{28} \times 14$ g of $H_2 \Rightarrow 3$ g of H_2.

For 28g of N_2 + 6g or H_2, i.e. 28g of N_2 reacts with 6 g of H_2 (by equation I).

27. $\underset{0.5}{3BaCl_2} + \underset{0.2}{2Na_3PO_4} \longrightarrow Ba_3(PO_4)_2 + 6NaCl$

As, 3 moles of $BaCl_2$ required

$= 2$ moles of Na_3PO_4

$\therefore$ 0.5 moles of $BaCl_2$ required

$= \frac{2}{3} \times 0.5$

$= 0.33$ moles of Na_3PO_4

$\therefore Na_3PO_4$ is the limiting reagent.

$\because$ 2 moles of Na_3PO_4 gives $Ba_3(PO_4)_2 = 1$ mol

$\therefore$ 0.2 mole of $Na_3(PO_4)$ gives

$Ba_3(PO_4)_2 = \frac{1}{2} \times 0.2$

$= 0.10$ mol

28. Volume of a gas at STP $= 22.4$ L

$\underset{22.4\,L}{C_3H_8} + \underset{5 \times 22.4\,L}{5O_2} \longrightarrow 3CO_2 + 4H_2O$

$\because$ To burn 22.4 L C_3H_8, the oxygen required

$= 5 \times 22.4$ L

$\therefore$ To burn 1 L C_3H_8,

the oxygen required will be $= \frac{5 \times 22.4}{22.4} = 5$ L

29. $\underset{\substack{207.2+16 \\ =223.2 \\ 1\ mol}}{PbO} + \underset{\substack{2(35.5+1) \\ =73 \\ 2\ mol}}{2HCl} \longrightarrow \underset{\substack{207.2+71 \\ =278.2 \\ 1\ mol}}{PbCl_2} + H_2O$

Given, mass of PbO = 6.5 g

mass of HCl = 3.2 g

$n_{PbO} = \frac{W_{PbO}}{M_{PbO}}$

$= \frac{6.5\,g}{223.2\ g/mol} = 0.029$ mol

$n_{HCl} = \frac{W_{HCl}}{M_{HCl}}$

$= \frac{3.2\,g}{36.5\ g/mol} = 0.087$ mol

2 moles of HCl reacts with 1 mole of PbO

$\therefore$ 0.087 mole of HCl reacts with

$\frac{1}{2} \times 0.087$ mole of PbO $= 0.0435$ mol of PbO.

But the given number of mole of PbO is 0.029 mole.

$\therefore$ PbO is the limiting reagent.

1 mole of PbO gives 1 mole of $PbCl_2$

$\therefore$ 0.029 mole of PbO gives 0.029 mole of $PbCl_2$.

30. $\underset{1\,g}{M_2CO_3} + 2HCl \longrightarrow 2M\,Cl + H_2O + \underset{0.01186\ mol}{CO_2}$

Number of moles of M_2CO_3 reacted = Number of moles of CO_2 evolved

$1/M = 0.01186$ [M = molar mass of M_2CO_3]

$\Rightarrow \quad M = \frac{1}{0.01186} = 84.3\ g\ mol^{-1}$

31. Molarity

$= \frac{\text{Weight of } HNO_3}{\text{Molecular mass of } HNO_3 \times \text{Volume of solution (in L)}}$

$\therefore$ Weight of HNO_3 = Molarity $\times$ Molecular mass $\times$ Volume (in L)

$= 2 \times 63 \times \frac{250}{1000}$

$= 31.5$ g

It is the weight of 100% HNO_3.

But the given acid is 70% HNO_3.

$\therefore$ Its weight $= 31.5 \times \frac{100}{70}$ g

$= 45.0$ g conc. HNO_3

32. Mohr's salt is $[FeSO_4 \cdot (NH_4)_2SO_4 \cdot 6H_2O]$

Only oxidisable part is Fe^{2+}

$$[Fe^{2+} \longrightarrow Fe^{3+} + e^-] \times 6$$

$$Cr_2O_7^{2-} + 14H^+ + 6e^- \longrightarrow 2Cr^{3+} + 7H_2O$$

$$6Fe^{2+} + Cr_2O_7^{2-} + 14H^+ \longrightarrow 6Fe^{3+} + 2Cr^{3+} + 7H_2O$$

Millimoles of $Fe^{2+} = 750 \times 0.6 = 450$

$$\text{Moles of } Fe^{2+} = \frac{450}{1000} = 0.450 \text{ mol}$$

$$6 \text{ moles of } Fe^{2+} \equiv 1 \text{ mol } Cr_2O_7^{2-}$$

$$\therefore 0.450 \text{ mole } Fe^{2+} \equiv \frac{0.450}{6} = 0.075 \text{ mol } Cr_2O_7^{2-}$$

$$= 0.075 \times 294$$

$$= 22.05 \text{ g}$$

33. $$\text{Normality } (N) = \frac{w \times 1000}{M \times V\,(\text{mL})}$$

$$= \frac{10 \times 1000}{60 \times 100} = 1.66$$

$$\therefore \quad N = 1.66 \text{ N} \Rightarrow N \approx 1.7 \text{ N}$$

34. $$M_1V_1 = M_2V_2$$

$$5 \times 500 = M_2 \times 1500$$

$$\frac{5 \times 500}{1500} = M_2$$

$$M_2 = 1.66 \text{ M}$$

35. As, normality = molarity × valence factor for H_2SO_4,

valence factor for $H_2SO_4 = 2$

$\therefore$ Normality, $N = M \times 2$

or $$M = \frac{N}{2} = \frac{0.02}{2} = 0.01 \text{ M}$$

Moles of H_2SO_4

$$= \frac{0.01 \times 100}{1000} = 1 \times 10^{-3} \text{ mol}$$

$$\left[\because \text{Molarity} = \frac{\text{Number of moles of solute}}{\text{Volume in solution (in mL)}} \times 1000\right] \quad \therefore$$

Number of molecules in 100 mL of 0.02 N $H_2SO_4 = 1 \times 10^{-3} \times N_A$

$$= 1 \times 10^{-3} \times 6.023 \times 10^{23}$$

$$= 6.023 \times 10^{20} \text{ molecules}$$

36. Molarity (M)

$$= \frac{\text{Mass of solute (in g)}}{\text{Molecular weight of solute} \times \text{volume of solution (in L)}} = \frac{22.2 \text{ g}}{111 \text{ g mol}^{-1} \times 1 \text{ L}}$$

$[\because$ Molecular weight of $CaCl_2 = 111 \text{ g mol}^{-1}]$

$= 0.2 \text{ mol L}^{-1} = 0.2$ M.

37. $$\text{Molarity } (M) = \frac{\text{Moles of solute}}{\text{Volume of solution (in L)}}$$

Moles of urea $= 120/60 = 2$

Weight of solution

= Weight of solvent + Weight of solute

$= 1000 + 120 = 1120$ g

$$\Rightarrow \text{Volume} = \frac{1120 \text{ g}}{1.15 \text{ g / mL}} \times \frac{1}{1000 \text{ mL}} = 0.973 \text{ L}$$

$\therefore$ Molarity $= 2/0.973 = 2.05$ M

38. Molar mass of the sugar, $(C_{12}H_{22}O_{11})$

$$m = (12 \times 12.01) + (22 \times 1.0079) + (11 \times 16.00)$$

$$= 342.2938 \text{ g mol}^{-1}$$

$$\approx 342 \text{ g mol}^{-1}$$

Given, $w = 20$ g, $V = 2$ L

$$\text{Molarity} = \frac{w}{m \times V \text{ (in L)}}$$

$$= \frac{20}{342 \times 2} = 0.0292 \text{ mol L}^{-1}$$

$$= 0.0292 \text{ M}$$

39. Molality is defined as the number of moles of solute present in 1 kg of solvent. It is denoted by m.

$$\text{Thus, molality } (m) = \frac{\text{Moles of solute}}{\text{Mass of solvent (in kg)}} \quad \text{...(i)}$$

Given that, Mass of solvent $(H_2O) = 500$ g $= 0.5$ kg

Weight of HCl = 18.25 g

Molecular weight of HCl $= 1 \times 1 + 1 \times 35.5 = 36.5$ g

$$\text{Moles of HCl} = \frac{18.25}{36.5} = 0.5$$

$$m = \frac{0.5}{0.5} = 1 \text{ m} \qquad \text{[from eq. (i)]}$$

40. Given, molarity = 2M

[i.e. 2 moles NaOH is dissolved in 1 L solution]

Density $(d) = 1.28 \text{ g/cm}^3$

Molecular weight of NaOH $= 40 \text{ g mol}^{-1}$

We know that,

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

$\therefore$ Mass of solution $= 1.28 \text{ g cm}^{-3} \times 1000 \text{ mL}$
$= 1280 \text{ g}$

Moreover,

$$\text{Molarity} = \frac{\text{Number of moles of solute}}{\text{Volume of solution (in L)}}$$

$$\therefore \quad 2 = \frac{\text{mass of solute}}{40 \times 1}$$

Mass of solute $= 80$ g

Now, mass of solution = mass of solvent + mass of solute

1280 g = mass of solvent +80

$\therefore$ Mass of solvent $= 1280 - 80 = 1200$ g
$= 1.2$ kg

$$\text{Now, molality} = \frac{\text{number of moles of solute}}{\text{mass of solvent (in kg)}}$$

$$= \frac{2}{1.2} = \frac{20}{12} = \frac{5}{3} = 1.67 \text{ m}$$

Alternative method

$$\text{Molality } (m) = \frac{M}{1000d - M\text{wt.}} \times 1000$$

where, M = molarity, d = density of solution

Mwt. = molar mass of solute.

On substituting the given values

$$\text{Molality} = \frac{2}{1000 \times 1.28 - 40} \times 1000$$

$$= \frac{2}{1280 - 40} \times 1000 = \frac{2000}{1240} = 1.612 \text{ m}$$

41. Volume of 100 g sample $= \dfrac{\text{Mass}}{\text{Density } (d)} = 100/d$

$$\text{Molarity} = \frac{\text{Mass of solute}}{\text{Molar mass of solute}} \times \frac{1000}{\text{Volume of solution (in mL)}}$$

$$\text{Molarity} = \frac{69}{63} \times \frac{1}{100/d} \times 1000$$

$$15.44 = \frac{69}{63} \times \frac{1}{100/d} \times 1000$$

$$d = \frac{63 \times 15.44}{69 \times 10} = 1.409 \text{ g/cc} \approx 1.41 \text{ g/cc}$$

42. 1.00 molar aqueous solution

= 1.0 mole in 1000 g water

$n_{\text{solute}} = 1$; $w_{\text{solvent}} = 1000$ g

$$n_{\text{solvent}} = \frac{1000}{18} = 55.56$$

$$\Rightarrow \quad \chi_{\text{solute}} = \frac{n_{\text{solute}}}{n_{\text{solute}} + n_{\text{solvent}}}$$

$$\chi_{\text{solute}} = \frac{1}{1 + 55.56} = 0.0177$$

43. Mole fraction of solute

$$= \frac{\text{number of moles of solute + number of moles of solvent}}{\text{number of moles of solute}}$$

$$\chi_{\text{solute}} = \frac{n_{\text{solute}}}{n_{\text{solute}} + n_{\text{solvent}}} = \frac{\dfrac{w_{\text{solute}}}{Mw_{\text{solute}}}}{\dfrac{w_{\text{solute}}}{Mw_{\text{solute}}} + \dfrac{w_{\text{solvent}}}{Mw_{\text{solvent}}}}$$

Given, $w_{\text{solute}} = w_{\text{NaOH}} = 8$ g

$Mw_{\text{solute}} = Mw_{\text{NaOH}} = 40 \text{ g mol}^{-1}$

$w_{\text{solvent}} = w_{H_2O} = 18$ g;

$Mw_{\text{solvent}} = 18 \text{ g mol}^{-1}$

$$\therefore \quad \chi_{\text{solute}} = \chi_{\text{NaOH}} = \frac{8/40}{8/40 + 18/18}$$

$$= \frac{0.2}{0.2 + 1} = \frac{0.2}{1.2} = 0.167$$

$$\text{Now, molality } (m) = \frac{\text{Moles of solute}}{\text{Mass of solvent (in kg)}}$$

$$= \frac{\dfrac{w_{\text{solute}}}{Mw_{\text{solute}}}}{w_{\text{solvent}} \text{ (in g)}} \times 100$$

$$= \frac{8/40}{18} \times 1000 = \frac{0.2}{18} \times 1000$$

$$= 11.11 \text{ mol kg}^{-1}$$

44. A $\rightarrow$ (4); B $\rightarrow$ (5); C $\rightarrow$ (3); D $\rightarrow$ (1); E $\rightarrow$ (2).

45. A $\rightarrow$ (3); B $\rightarrow$ (2); C $\rightarrow$ (1); D $\rightarrow$ (4).

46. Assertion is correct but Reason is incorrect. 0.200 contains 3 while 200 contains only one significant figure because zero at the end or right of a number are significant provided they are on the right side of the decimal point.

47. Both Assertion and Reason are correct and Reason is the correct explanation of Assertion.

48. Thus, Assertion is incorrect but Reason is correct.

1.231 has four significant figures. All numbers from left to right are counted, starting with the first digit that is not zero for calculating the number of significant figures.

49. Eq. wt. of Cu in CuO $= \frac{\text{At. wt.}}{\text{Valency}} = \frac{63.6}{2} = 31.8$ and CuO is 63.6.

Both Assertion and Reason are correct and Reason is the correct explanation of Assertion.

50. Both Assertion and Reason are correct and Reason is the correct explanation of Assertion. The molecular formula of ethene is C_2H_4 and its empirical formula is CH_2.

Thus, molecular formula = empirical formula $\times 2$

51. Volume occupied by a gas changes with change in temperature and pressure. For example, change in temperature increases the K.E. of the molecules and gases expand and hence, occupy more volume.

Both Assertion and Reason are correct but Reason is not the correct explanation of Assertion.

52. According to law of conservation of mass, in a chemical reaction total mass of the products is equal to the total mass of the reactants.

Both Assertion and Reason are correct and Reason is the correct explanation of Assertion.

53. Both Assertion and Reason are correct but Reason is not the correct explanation of Assertion.

Atomic masses of the elements obtained by scientists by comparing with the mass of carbon comes out to be close to whole number value.

54. Number of atoms present in a molecule of a gaseous element is called atomicity.

e.g. O_2 has two atoms and hence, its atomicity is 2. Both Assertion and Reason are correct but Reason is not the correct explanation of Assertion.

55. No. of gram molecules

$$= \frac{\text{wt. of sub.}}{\text{GMM}} \text{ (GMM = Gram molecular mass)}$$

$\therefore$ GMM of $SO_2Cl_2 = 135$ g

Thus, Assertion is incorrect but Reason is correct.

56. One mole of any substance corresponds to 6.023×10^{23} entities irrespective of its weight.

Molecular weight of

$$SO_2 = 32 + 2 \times 16 = 64 \text{ g mol}^{-1}$$

Molecular weight of $O_2 = 2 \times 16 = 32 \text{ g mol}^{-1}$

Therefore, molecular weight of SO_2 is double to that of O_2.

Thus, Assertion is correct but Reason is incorrect.

57. This is vapour density method for determination of molecular weight.

Both Assertion and Reason are correct and Reason is the correct explanation of Assertion.

58. Assertion is correct but Reason is incorrect. Combustion of 16 g of methane gives 36 g of water.

$$\underset{\substack{1\text{mol} \\ = 16 \text{ g}}}{CH_4} + 2O_2 \longrightarrow CO_2 + \underset{\substack{2 \text{ mol} \\ = 36 \text{ g}}}{2H_2O}$$

59. The amount of product formed will be decided by the amount of limiting reagent.

Both Assertion and Reason are correct and Reason is the correct explanation of Assertion.

60. Concentration means how much amount of substance (solute) is present in a given volume of a solution.

Now, as amount can be measured in terms of moles, so molarity means concentration of the solution.

Both Assertion and Reason are correct and Reason is the correct explanation for Assertion.

61. (i) $CuSO_4 \cdot 5H_2O$ has 1 mole of Cu and 9 moles of oxygen atoms.

$$63.5 \text{ g of Cu} = 9 \times 16 \text{ g of oxygen}$$

$$8.64 \text{ g of oxygen} = \frac{63.5}{9 \times 16} \times 8.64 = 3.81 \text{ g}$$

(ii) Equal volumes contain equal number of moles. Hence, molar ratio of He : CH_4 = 1 : 1

$\therefore$ Ratio by weight $= 4 : 16 = 1 : 4$

$\therefore$ CH_4 present by weight $= \frac{4}{5} \times 100 = 80\%$

(iii) 22.4 L of O_2 gas at STP = 1 gram molecule (1 mole)

5.6 L of O_2 gas at STP $= \frac{1}{22.4} \times 5.6$ of gram molecule

$= \frac{1}{4}$ gram molecule $= \frac{1}{4} \times 2$ gram atoms $= \frac{1}{2}$ gram atom

(iv) Yellow phosphorus is an allotropic form of phosphorus with molecular formula P_4.

$\therefore$ Molecular mass of yellow phosphorus

$$(P_4) = 4 \times 30$$
$$= 120 \text{ g mol}^{-1}$$

1 mole of $P_4 = 6.022 \times 10^{23}$ molecules $= 120$ g

$\therefore$ Mass of one molecule of P_4

$$= \frac{120}{6.022 \times 10^{23}}$$
$$= 1.993 \times 10^{-22} \text{ g}$$
$$= 1.993 \times 10^{-19} \text{ mg}$$

Or

In 1 L of air, volume of $O_2 = 210$ cc

$22400 \text{ cm}^3 = 1$ mol

$$210 \text{ cm}^3 = \frac{210}{22400} = 0.0093 \text{ mol}$$

62. (i) 1 L NH_3 will react with 1 L HCl to form NH_4Cl which has negligible volume.

Hence, final mixture will contain only 0.5 L HCl.

(ii) $$\underset{\substack{1 \text{ mol} \\ 22.4 \text{ L}}}{H_2(g)} + \underset{\substack{1 \text{ mol} \\ 22.4 \text{ L}}}{Cl_2(g)} \longrightarrow \underset{\substack{2 \text{ mol} \\ 2 \times 36.5 \text{ g}}}{2HCl(g)}$$

For the formation of 3.65 g HCl, H_2 or Cl_2 required $= \frac{22.4}{2 \times 36.5} \times 3.65 = 1.12$ L

(iii) Equal volumes of gases contain equal number of moles.

Hence, molar ratio of He : CH_4 = 1 : 1

Ratio by weight = 4 : 16 = 1 : 4

$\therefore$ CH_4 present by weight $= \frac{4}{5} \times 100 = 80\%$

(iv) $$\underset{x}{AgNO_3} + \underset{5.85}{NaCl} \longrightarrow \underset{14.35}{AgCl} + \underset{8.5}{NaNO_3}$$

$$x + 5.85 = 14.35 + 8.5$$
$$x = 17.0 \text{ g}$$

Or

Urea is NH_2CONH_2

1 mol = 60 g

There are two nitrogen atoms in urea.

Weight of nitrogen = 28 g

$\therefore \frac{28}{60} \times 100$ = weight percent of N = 46%

63. (i) Both Assertion and Reason are correct and Reason is the correct explanation of Assertion.

Molar volume (at NTP) = 22.4 L

Now 22.4 L of N_2 = volume occupied by 1 mole of N_2 = 28 g = 6.023×10^{23} molecules.

Similarly, 1 mole of $O_2 = 2 \times 16 = 32$ g

$= 6.023 \times 10^{23}$ molecules = 22.4 L

$\therefore$ 22.4 L = 6.023×10^{23} molecules

(ii) Both Assertion and Reason are correct and Reason is the correct explanation of Assertion.

(iii) Both Assertion and Reason are correct and Reason is the correct explanation of Assertion.

44 g of CO_2 = 1 mole ≡ 1 g atom of C

16 g of CH_4 = 1 mole ≡ 1 g atom of C

1 g atom of C = 12 g of C

12 g of C contains 6.023×10^{23} carbon atoms.

(iv) Both Assertion and Reason are correct but Reason is not the correct explanation of Assertion.

The number of moles of a solute present in a litre of solution is known as molarity (M).

The total number of molecules of reactants present in a balanced chemical equation is known as molecularity. For example,

$PCl_5 \longrightarrow PCl_3 + Cl_3$ (Unimolecular)

$2HI \longrightarrow H_2 + I_2$ (Bimolecular)

Therefore, molarity and molecularity are used in different sense.

Or

Both Assertion and Reason are correct but Reason is not the correct explanation of Assertion.

Molar mass or mass of 1 mole of NaCl

= 23 + 35.5 = 58.5 g

According to mole concept,

1 mole of a compound

$= 6.023 \times 10^{23}$ molecules

$\therefore$ 58.5 g of NaCl also contains 6.023×10^{23} molecules of NaCl.

64. (i) Both Assertion and Reason are correct but Reason is not the correct explanation of Assertion.

(ii) Assertion is correct but Reason is incorrect.

Mole fraction of A is solution $(\chi_A) = \dfrac{n_A}{n_A + n_B}$

Mole fraction of B is solution $(\chi_B) = \dfrac{n_B}{n_A + n_B}$

So, $\chi_A + \chi_B = \dfrac{n_A + n_B}{n_A + n_B} = 1$

The moles of any substances is related to its mass and mass is independent of temperature.

Thus, Assertion is correct but Reason is incorrect.

(iii) Both Assertion and Reason are correct and Reason is the correct explanation of Assertion.

Concentration mean how much amount of substance solute is present in a given volume of a solution. Now, as amount can be measured in terms of moles so molarity means concentration of the solution.

(iv) Molality of solution does not change with temperature as it depend on the mass and mass remain unaffected with temperature.

$$\text{Molality}, m = \frac{\text{Moles of solute}}{\text{Weight of solvent (in g)}} \times 1000$$

Thus, both Assertion and Reason are correct statements and Reason is the correct explanation of Assertion.

Or

Assertion is incorrect but Reason is the correct statement.

Molarity (M) is calculated by following equation.

$$\text{Molarity} = \frac{\text{Weight} \times 1000}{\text{Molecular weight} \times \text{Volume (mL)}}$$

Thus, molarity of solution depends upon temperature as it depend on volume.