DAY ONE

Some Basic Concepts of Chemistry

Learning & Revision for the Day

- Matter and its Nature
- Physical Quantities and their Measurements
- Laws of Chemical combinations
- Dalton's Atomic Theory
- Equivalent Weight
- Mole Concept and Molar Mass
- Chemical Equations and Stoichiometry
- Various Concentration Terms

Chemistry is the branch of science which deals with the composition, properties and interaction of all kinds of matter such as air, water, rocks, plants, earth etc.

Matter and Its Nature

Anything that occupies space and possesses mass is called **matter**. On the basis of physical state of substance, matter is divided into three types:

1. **Solids** have definite volume and definite shape.
2. **Liquid** have definite volume but not the definite shape.
3. **Gases** have neither definite volume nor definite shape.

On the basis of chemical composition of substance. It is of three types:

(i) **Elements** These are the substances that cannot be decomposed into simpler substances by chemical change.

(ii) **Compounds** These can be decomposed into simpler substances by chemical changes. Compound is always homogeneous.

(iii) **Mixtures** These have variable composition and variable properties due to the fact that components retain their characteristic properties. Components of a mixture can be separated by applying physical methods.

Every substance has unique property and these can be measured qualitatively and quantitatively.

Physical Quantities and Their Measurements

- Mass, length, time and temperature are physical quantities. These are expressed in numerals with suitable units. Units may be basic (fundamental) or derived.
- The **SI system** has seven base units. These units pertain to the seven fundamental scientific quantities. The units of mass (kg), length (m), time (s), electric current (A),

temperature (K), luminous intensity (cd), and amount of substance (mol) are fundamental units.

- The lowest temperature permitted in nature is $-273.15°C$ (0 K). This temperature is known as **absolute zero**.
- Relationship between Celsius and Kelvin scale is $K = °C + 273.15$.
- Relationship between the Celsius and Fahrenheit scales are related as $°C = \frac{5}{9}(°F - 32)$
- A number of quantities must be derived from measured value of the SI base quantities. These are called **derived units**. e.g. Units of density ($kg\ m^{-3}$) is derived from the units of mass (kg) and volume (m^3).

NOTE
- The term **precision** refers for the closeness of the set of values obtained from identical measurements of a quantity. Precision is simply a measure of reproducibility of an experiment.
- **Accuracy**, a related term, refers to the closeness of a single measurement to its true value.

Significant Figures

Significant figures are meaningful digits which are known with certainty. These are the total number of digits in a number including last digit whose value is uncertain. The uncertainty is indicated by writing the certain digits and the last uncertain digit.

Certain rules for determining the number of significant figures are as follows

- Read the number from left to right and count all the digits, starting with the first digit that is non-zero.
- In addition or subtraction, the number of decimal places in the answer should not exceed the number of decimal places in either of the numbers.
- In multiplication and division, the result should be reported to the same number of significant figures as that in the quantity with least number of significant figures.
- When a number is rounded off, the number of significant figures is reduced. The last digit retained is increased by 1 only if the following digit is ≥ 5 and is left as such if the following digit is ≤ 4.

Dimensional Analysis

In calculations, many of the times it become necessary to convert units from one system to another. This is achieved by factor label method or unit factor method or dimensional analysis. The dimensions of a derived quantity are the powers to which the basic quantities have to be raised in a product defining the quantity. Dimensional analysis involves calculations based on the fact that if two quantities have to be equated, they must have the same dimensions or the same units.

Laws of Chemical Combinations

The combination of elements to form compounds is governed by the following basic laws:

1. **Law of conservation of mass** (Lavoisier, 1789)
   Total mass of reactants = total mass of products.
2. **Law of constant composition/Definite proportions** (Proust, 1799) For the same compound, obtained by different methods, the percentage of each element should be same in each case.
3. **Law of multiple proportions** (Dalton, 1803) An element may form more than one compound with another element. For a given mass of an element, the masses of other elements (in two or more compounds) are in the ratio of small whole numbers. For example, in NH_3 and N_2H_4, fixed mass of nitrogen requires hydrogen in the ratio 3 : 2.
4. **Law of equivalent/reciprocal proportions** (Ritcher, 1794) When two different elements combines with a fixed weight of a third element, the ratio of their combination will either be same or multiple of the ratio in which they combine with each other. e.g. CH_4, CO_2 and H_2O.
5. **Law of combining volumes** (Gay-Lussac, 1808) It states that when gases combine or are produced in a chemical reaction they do so in a simple ratio by volume provided all gases are at same temperature and pressure.
6. **Avogadro's Law** It states that equal volume of all gases at same temperature and pressure should contain equal number of molecules.

Dalton's Atomic Theory

John Dalton developed his famous theory of atoms in 1808. The main postulates of this theory were:

- Atom was considered as hard, dense and smallest indivisible particle of matter.
- Atom is indestructible i.e. it cannot be destroyed or created in a chemical reaction.
- Atom is the smallest portion of matter which takes part in chemical combination.
- Atoms combine with each other, to form compound (or molecules) in simple whole number ratio.
- Atoms of same elements are identical in mass and chemical properties.
- Chemical reactions involve reorganisation of atoms. These are neither created nor destroyed in a chemical reaction.

Atomic, Molecular and Formula Masses

1. **Atomic Mass** It is defined as the number which indicates how many times the mass of one atom of the element is heavier as compared to $\frac{1}{12}$th part of the mass of one atom of C-12.

2. The **gram atomic mass** of an element should not be mass of their atoms. e.g. Gram atomic mass of H-element is 1.008 g but mass of H-atoms is 1 μ [1.67×10^{-24} g].

The approximate atomic mass of solid elements except Be, B, C and Si, is related to specific heat as

$$\text{Average atomic mass} = \frac{6.4}{\text{specific heat}}$$

(from Dulong and Petit's law for metals)

Exact atomic mass = Equivalent mass × valency

As most of the elements have isotopes, so their actual atomic mass is the average of atomic masses of all the isotopes.

Average atomic mass is calculated as

$$M_{av} = \frac{m_1 \times r_1 + m_2 \times r_2 + m_3 \times r_3}{r_1 + r_2 + r_3}$$

where, r_1, r_2 and r_3 = relative abundances of the isotopes.

3. **Molecular Mass** It is the sum of atomic masses of the elements present in a molecule. It is obtained by multiplying the atomic mass of each element by the number of its atoms and adding them together.
4. **Formula Mass** It is the sum of the atomic masses of all atoms in the formula unit of the compound. It is normally calculated for ionic compounds. Formula mass of NaCl is $23 + 35.5 = 58.5$ amu or 58.5u.

Equivalent Weight

It is the weight of an element or of a compound, which would combine with or displace (by weight) 1 part of hydrogen or 8 parts of oxygen or 35.5 parts of chlorine.

Equivalent weight. (Eq. wt.)

$$= \frac{\text{atomic wt. or molecular wt.}}{\text{'}n\text{' factor}}$$

'n' factor for various compounds can be obtained as :

1. **'*n*' factor for acids, i.e. basicity** is the number of ionisable H^+ per molecule is the basicity of acids. e.g. basicity of HCl = 1
2. **'*n*' factor for bases, i.e. acidity** is the number of ionisable OH^- per molecule is the acidity of bases. e.g. Acidity of NaOH = 1
3. **'*n*' factor for salt** is total positive or negative charge of ions. e.g. $Na_2CO_3 \longrightarrow 2Na^+ + CO_3^{2-}$
4. **'*n*' factor for ion** is equal to charge of that ion.

   e.g. $E_{Cl^-} = \frac{35.5}{1} = 35.5$
5. **In redox titration**, n factor for reducing agent is number of electrons lost by the molecule and for oxidising agent is number of electron gained by the molecule.

   e.g. $FeSO_4$ ⇒ As reducing agent

   $Fe^{2+} \longrightarrow Fe^{3+} + e^-$ 'n' factor = 1

   ⇒ As an oxidising agent

   $Fe^{2+} + 2e^- \longrightarrow Fe(s)$ 'n' factor = 2

- Equivalent mass of oxidising / reducing agent

$$= \frac{\text{molecular mass of oxidising / reducing agent}}{\text{number of electrons gained or lost by one molecule}}$$

Mole Concept and Molar Mass

- Mole is the amount of substance which contains 6.022×10^{23} (Avogadro's number) particles and has mass equal to gram-atomic mass or gram-molecular mass.
- Mole is related to the mass of the substance (in grams), volume of gaseous substance and number of particles. Therefore, number of moles

$$= \frac{\text{Mass of substance (g)}}{\text{Molar mass (g mol}^{-1})}$$

$$= \frac{\text{Volume of gas at STP (L)}}{22.4\,(\text{L})}$$

$$= \frac{\text{Number of particles at STP}}{N_A}$$

- Moles of atoms/molecules/ions/ electrons
  $= N_A \times$ Number of atoms/molecules/ions/electrons
- Total charge present on an ion
  = mole × N_A × charge on one ion × 1.6×10^{-19} C
- **Molar mass** of an element is defined as mass of 1 mole of a substance in grams, i.e. mass of 6.023×10^{23} entities or particles of that element.

Percentage Composition, Empirical and Molecular Formulae

- The percentage of any element or constituent in a compound is the number of parts by mass of that element or constituent present in two parts, by mass of the compound.

  Mass % of an element

$$= \frac{\text{mass of element in the compound} \times 100}{\text{molar mass of compound}}$$

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

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

  here, n is any integer such 1, 2, 3, … etc.

  Molecular formula = n × empirical formula

  Molecular/molar mass = 2 × vapour density

Chemical Equations and Stoichiometry

- A **balanced chemical equation** with suitable stoichiometric coefficients represent the ratio of number of moles of reactants and products.
- The chemical equation provides qualitative and quantitative information about a chemical change in a simple manner.
- Stoichiometry deals with calculation of masses of the reactants and the products involved in a chemical reaction.
- The numerals used to balance a chemical equation is called **stoichiometric coefficients**.
- For the stoichiometric calculations, the mole relationships between different reactants and products are required. The mass-mass, mass-volume and volume- volume relationship can be obtained between different reactants and products.

Limiting Reagent

- The substance which is completely consumed in a reaction is called limiting reagent. It determines the amount of product.

$$\text{Reaction yield} = \frac{\text{actual yield} \times 100}{\text{theoretical yield}}$$

- In stoichiometry, if the quantities of two or more reactants are given, the amount of products formed depend upon the limiting reactant (the reactant which consumed first in the reaction).

Various Concentration Terms

Different concentration terms are given below :

1. **Molarity** (M) It is defined as the number of moles of solute per litre of solution or as the number of mg-molecules per millilitre of solution. The molarity is usually designated by M. It is dependent upon the temperature, as it depends on volume which changes with temperature.
   e.g. if the molarity of H_3PO_4 is 0.18, it means a concentration corresponding to 0.18 mole of H_3PO_4 per litre of solution.
   Thus, molarity is given as

$$\text{Molarity, } (M) = \frac{\text{moles of solute}}{\text{volume of solution (in L)}}$$

If specific gravity is given,

$$\text{molarity} = \frac{\text{specific gravity} \times \text{\% strength} \times 10}{\text{molecular weight}}$$

If molarity and volume of solution are changed from m_1, V_1 to m_2, V_2 then

$$m_1V_1 = m_2V_2 \qquad \text{(molarity equation)}$$

If two solutions of the same solute are mixed the molarity of resulting solution

$$m_3 = \frac{m_1V_1 + m_2V_2}{V_1 + V_2}$$

Strength of solution (S)

Amount of solute present in 1 L solution

$$\text{Strength, } (S) = \frac{\text{weight of solute}}{\text{volume of solution (in L)}}$$

2. **Molality** (m) It is defined as the number of moles of solute dissolved in 1000 g of the solvent. It is designated by m. Molality is independent of temperature, as it depends only upon the mass which does not vary with temperature.

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

3. **Normality** (N) It is defined as the number of g-equivalents of solute per litre of solution or as the number of mg-equivalents of a substance per millilitre of solution. e.g. 0.12 N H_2SO_4 means a solution which contains 0.12 g-equivalent of H_2SO_4 per litre of solution.
   This also means that each millilitre of this solution can react, for example, with 0.12 mg-eq. of CaO or with 0.12 mg-eq. of Na_2CO_3. Thus,

$$\text{Normality } (N) = \frac{\text{gram-equivalent of solute}}{\text{volume of solution (in L)}}$$

or

$$= \frac{\text{gram-equivalent of solute}}{\text{volume of solution (in mL)}} \times 1000$$

If specific gravity is known, normality is calculated as

$$\text{Normality} = \frac{\text{specific gravity} \times \text{\% strength} \times 10}{\text{equivalent weight}}$$

If normality and volume of solution are changed from N_1, V_1 to N_2, V_2 then $N_1V_1 = N_2V_2$ if two solution of same solute are mixed then normality or resulting solution

$$N_3 = \frac{N_1V_1 + N_2V_2}{V_1 + V_2}$$

4. **Mole fraction** (χ) It is the ratio of number of moles of a particular component to the total number of moles of the solution.
   Thus, mole fraction is given as

$$\text{Mole fraction } (\chi) = \frac{\text{number of moles of component}}{\text{number of moles of solution}}$$

The sum of mole fractions of the component is equal to 1.

DAY PRACTICE SESSION 1

FOUNDATION QUESTIONS EXERCISE

1 The correctly reported answer of the addition of 4.523, 2.3 and 6.24 will have significant figures

(a) two (b) three
(c) four (d) five

2 A student performs a titration with different burettes and finds titre values of 25.2 mL, 25.25 mL and 25.0 mL. The number of significant figures in the average titre value is → AIEEE 2010

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

3 A metal oxide contains 53% metal and carbon dioxide contains 27% carbon. Assuming the law of reciprocal proportions, the percentage of metal in the metal carbide is

(a) 75% (b) 25%
(c) 37% (d) 66%

4 Two oxides of metal were found to contain 31.6% and 48% of oxygen respectively. If the formula of first is represented by M_2O_3, then formula of second is

(a) MO_3 (b) MO_2
(c) M_2O (d) M_2O_2

5 The equivalent weight of H_3PO_2, when it disproportionates into PH_3 and H_3PO_4, is

(a) 82 (b) 61.5
(c) 33 (d) 20.5

6 3g of an oxide of a metal is converted to chloride completely and it yielded 5 g of chloride.The equivalent weight of the metal is

(a) 33.25 (b) 3.325
(c) 12 (d) 20

7 Sea water contains 65×10^{-3} g L^{-1} of bromide ions. If all the bromide ions are converted to produce Br_2, how much sea water is needed to prepare 1 kg Br_2 ?

(a) 15.38 L (b) 15.38×10^3 L
(c) 7.69×10^3 L (d) 76.9 L

8 0.376 g of Al reacted with an acid to displace 0.468 L of H_2 measured in standard conditions. Equivalent volume of H_2 formed is (equivalent mass of Al is 9 g $equiv^{-1}$)

(a) 22.4 L (b) 5.6 L
(c) 11.2 L (d) 2.24 L

9 The same amount of a metal combines with 0.200 g of oxygen and with 3.17 g of a halogen. Hence, equivalent mass of halogen is

(a) 127 g (b) 80 g
(c) 35.5 g (d) 9 g

10 If we consider that 1/6 in place of 1/12, mass of carbon atom is taken to be the relative atomic mass unit, the mass of one mole of a substance will

(a) to be a function of the molecular mass of the substance
(b) remain unchanged
(c) increase two fold
(d) decrease twice

11 How many moles of magnesium phosphate, $Mg_3(PO_4)_2$ will contain 0.25 mole of oxygen atoms?

(a) 0.02 (b) 3.125×10^{-2}
(c) 1.25×10^{-2} (d) 2.5×10^{-2}

12 Rearrange the following (I to IV) in the order of increasing masses and choose the correct answer
(atomic mass; O = 16, Cu = 63, N = 14)

I. 1 molecule of oxygen.
II. 1 atom of nitrogen.
III. 1×10^{-10} g molecular weight of oxygen.
IV. 1×10^{-10} g atomic weight of copper.

(a) II < I < III < IV (b) IV < III < II < I
(c) II < III < I < IV (d) III < IV < I < II

13 Number of atoms in the following samples of substances is largest in → JEE Main (Online) 2013

(a) 4.0 g of hydrogen (b) 70.0 g of chlorine
(c) 127.0 g of iodine (d) 48.0 g of magnesium

14 The total number of electrons present in 18 mL of water (density of water is 1 g mL^{-1}) is

(a) 6.02×10^{23} (b) 6.02×10^{23}
(c) 6.02×10^{24} (d) 6.02×10^{25}

15 The weight of 1×10^{22} molecules of $CuSO_4 \cdot 5H_2O$ is

(a) 41.59 g (b) 415.9 g
(c) 4.159 g (d) None of these

16 The number of moles of $(NH_4)_2SO_4Fe_2(SO_4)_3 \cdot 24H_2O$ formed from a sample containing 0.0056 g of Fe is

(a) 10^{-4} mol (b) 0.5×10^{-4} mol
(c) 2×10^{-4} mol (d) 0.33×10^{-4} mol

17 If 10^{21} molecules are removed from 200 mg of CO_2, the number of moles of CO_2 left are

(a) 2.88×10^{-3} (b) 28.8×10^{-3}
(c) 0.288×10^{-3} (d) 1.66×10^{-2}

18 Medical experts generally consider a lead level of 30 μg Pb per dL of blood to pose a significant health risk (1 dL = 0.1 L). Express this lead level as the number of Pb atoms per cm^3 blood (Pb = 207).

(a) 8.72×10^{14} (b) 8.72×10^{15}
(c) 8.72×10^{13} (d) 8.72×10^{16}

19 Which of the following pairs of gases contains the same number of molecules ?

(a) 16 g of O_2 and 14 g of N_2

(b) 8 g of O_2 and 22 g of CO_2

(c) 28 g of N_2 and 22 g of CO_2

(d) 32 g of O_2 and 32 g of N_2

20 The number of H-atoms present in 25.6 g of sucrose which has a molar mass of 342.3 g is

(a) 22×10^{23} (b) 9.91×10^{23} (c) 11×10^{23} (d) 44×10^{23}

21 The most abundant elements by mass in the body of a healthy human adult are oxygen (61.4%), carbon (22.9%), hydrogen (10.0%) and nitrogen (2.6%). The weight which a 75 kg person would gain if all H atoms are replaced by ^2H atoms is

(a) 15 kg (b) 37.5 kg (c) 7.5 kg (d) 10 kg

22 A gaseous hydrocarbon gives upon combustion 0.72 g of water and 3.08 g of CO_2. The empirical formula of the hydrocarbon is ➞ JEE Main (Online) 2013

(a) C_2H_4 (b) C_3H_4 (c) C_6H_5 (d) C_7H_8

23 A 0.2075 g sample of an oxide of cobalt on analysis was found to contain 0.1475 g cobalt. The empirical formula of the oxide is

(a) CoO_2 (b) Co_2O_3

(c) CoO (d) Co_4O_6

24 At 300 K and 1 atom, 15 mL of a gaseous hydrocarbon requires 375 mL air containing 20% O_2 by volume for complete combustion. After combustion, the gases occupy 330 mL. Assuming that the water, formed is in liquid form and the volumes were measured at the same temperature and pressure, the formula of the hydrocarbon is ➞ JEE Main 2016

(a) C_3H_8 (b) C_4H_8

(c) C_4H_{10} (d) C_3H_6

25 The ratio of mass per cent of C and H of an organic compound ($C_xH_yO_z$) is 6 : 1. If one molecule of the above compound ($C_xH_yO_z$) contains half as much oxygen as required to burn one molecule of compound C_xH_y completely to CO_2 and H_2O. The empirical formula of compound $C_xH_yO_z$ is ➞ JEE Main 2018

(a) $C_3H_6O_3$ (b) C_2H_4O

(c) $C_3H_4O_2$ (d) $C_2H_4O_3$

26 A mixture of FeO and Fe_3O_4 when heated in air to constant weight, gains 5% in its weight. What is the percentage of Fe_3O_4 in mixture?

(a) 73.87% (b) 26.13%

(c) 79.75% (d) 20.25%

27 1.00×10^{-3} moles of Ag^+ and 1.00×10^{-3} moles of CrO_4^{2-} react together to form solid Ag_2CrO_4.Calculate the amount of Ag_2CrO_4 formed (Ag_2CrO_4 = 331.73 g mol^{-1}).

(a) 0.268 g (b) 0.166 g

(c) 0.212 g (d) 1.66 g

28 Mixture X = 0.02 mole of $[Co(NH_3)_5SO_4]$ Br and 0.02 mole of $[Co(NH_3)_5Br]$ SO_4 was prepared in 2 L of solution.

1 L of mixture X + excess $AgNO_3 \longrightarrow Y$

1 L of mixture X + excess $BaCl_2 \longrightarrow Z$

Number of moles of Y and Z are

(a) 0.01, 0.01 (b) 0.02, 0.01

(c) 0.01, 0.02 (d) 0.02, 0.02

29 How much AgCl will be formed by adding 200 mL of 5 N HCl to a solution containing 1.7 g $AgNO_3$ (Ag = 108)?

(a) 0.1435 g (b) 1.435 g

(c) 14.35 g (d) 143.5 g

30 If 0.5 mole of $BaCl_2$ are mixed with 0.2 mole of Na_3PO_4, the maximum number of moles of $Ba_3(PO_4)_2$ that can be formed, is

(a) 0.7 (b) 0.5

(c) 0.30 (d) 0.10

31 The reaction between yttrium metal and dil. HCl produces H_2S and y^{3+} ions. The molar ratio of yttrium to that hydrogen produced is

(a) 1:2 (b) 2:1

(c) 2:3 (d) 5:2

32 3 g of activated charcoal was added to 50 mL of acetic acid solution (0.06 N) in a flask. After an hour it was filtered and the strength of the filtrate was found to be 0.042 N. The amount of acetic acid adsorbed (per gram of charcoal) is ➞ JEE Main 2015

(a) 18 mg (b) 36 mg

(c) 42 mg (d) 54 mg

33 The molecular formula of a commercial resin used for exchanging ions in water softening is $C_8H_7SO_3Na$ (Mol. wt. = 206). What would be the maximum uptake of Ca^{2+} ions by the resin when expressed in mole per gram resin? ➞ JEE Main 2015

(a) 1/103 (b) 1/206 (c) 2/309 (d) 1/412

34 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) ➞ AIEEE 2011

(a) 0.49 g (b) 0.45 g

(c) 22.05 g (d) 2.2 g

35 5 mL of N HCl, 20 mL of $N/2$ H_2SO_4 and 30 mL of $N/3$ HNO_3 are mixed together and volume made to 1 L. The normality of resulting solution is

(a) 0.45 (b) 0.025 (c) 0.9 (d) 0.05

36 Two solutions of a substance (non-electrolyte) are mixed in the following manner : 480 mL of 1.5 M of first solution with 520 mL of 1.2 M of second solution. The molarity of final solution is

(a) 1.20 M (b) 1.50 M (c) 1.344 M (d) 2.70 M

Direction (Q.Nos. 37-38) *In the following questions assertion followed by a reason is given. Choose the correct answer out of the following choices.*

(a) Both A and R are true and R is correct explanation of A
(b) Both A and R are true but R is not correct explanation of A
(c) A is true but R is false
(d) Both A and R are false

37 **Assertion** (A) On changing volume of the solution by 20%, molarity of solution also changes by 20%.

Reason (R) Molar concentration or molarity of solution is not affected on dilution.

38 **Assertion** (A) If 30 mL of H_2 combines with 20 mL of O_2 to form water, 5 mL of H_2 left after the reaction.

Reason (R) O_2 is the limiting reagent.

DAY PRACTICE SESSION 2

PROGRESSIVE QUESTIONS EXERCISE

1 The reaction, $N_2 + 3H_2 \longrightarrow 2NH_3$ is used to produce ammonia. When 450 g of hydrogen was reacted with nitrogen, 1575 g of ammonia were produced. What is the per cent yield of this reaction?

(a) 61.8% (b) 41.5%
(c) 30.8% (d) 20.7%

2 A sample of ammonium phosphate, $(NH_4)_3PO_4$ contains 3.18 moles of hydrogen atoms. The number of moles of oxygen atoms in the sample is

(a) 0.265 (b) 0.795
(c) 1.06 (d) 3.18

3 1 mole of potassium chlorate is thermally decomposed and excess of aluminium is burnt in the gaseous product. How many moles of aluminium oxide are formed?

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

4 Amount of A $FeSO_4(NH_4)_2SO_4 \cdot 6H_2O$ (molar mass $= 392\,g\,mol^{-1}$) must be dissolved and diluted to 250 mL to prepare an aqueous solution of density $1.00\ g\ mL^{-1}$, i.e. 1.00 ppm Fe^{2+} by weight is

(a) 3.50×10^{-3} g (b) 1.75×10^{-3} g
(c) 7.00×10^{-3} g (d) 0.35×10^{-3} g

5 Excess of carbon dioxide is passed through 50 mL of 0.5 m calcium hydroxide solution. After completion of the reaction, the solution was evaporated to dryness. The solid calcium carbonate was completely neutralised with 0.1 N hydrochloric acid. The volume of hydrochloric acid required is (atomic mass of calcium = 40).

(a) 300 cm^3 (b) 200 cm^3
(c) 500 cm^3 (d) 400 cm^3

6 Sodium nitrate on reduction with Zn in the presence of NaOH solution produces NH_3. Mass of sodium nitrate absorbing 1 mole of electron will be

(a) 7.750 (b) 10.625
(c) 8.000 (d) 9.875

7 1 mole of N_2 and 4 moles of H_2 are allowed to react in a vessel and after reaction, H_2O is added. Aqueous solution required 1 mole of HCl. Mole fraction of H_2 in the gaseous mixture after reaction is

(a) $\frac{1}{6}$ (b) $\frac{5}{6}$
(c) $\frac{1}{3}$ (d) None of these

8 Potassium selenate is isomorphous with potassium sulphate and contains 50.0% of Se. Find the atomic weight of Se.

(a) 47.33 (b) 71
(c) 142 (d) 284

9 Acidified $KMnO_4$ oxidises oxalic acid to CO_2. What is the volume (in litres) of 10^{-4} M $KMnO_4$ required to completely oxidise 0.5 L of 10^{-2} M oxalic acid in acidic medium?

(a) 125 (b) 1250
(c) 200 (d) 20

10 Haemoglobin contains 0.33% of iron by weight. The molecular weight of haemoglobin is approximately 67200. The number of iron atoms (at. wt. of Fe is 56) present in one molecule of haemoglobin are

(a) 1 (b) 6
(c) 4 (d) 2

11 What volume of hydrogen gas at 273 K and 1 atm pressure will be consumed in obtaining 21.6 g of elemental boron (atomic mass = 10.8) from the reduction of boron trichloride by hydrogen ?

(a) 89.6 L (b) 67.2 L
(c) 44.8 L (d) 22.4 L

12 Density of 2.05 M solution of acetic acid in water is 1.02 g/mL. The molality of same solution is

(a) 1.14 mol kg^{-1} (b) 3.28 mol kg^{-1}
(c) 2.28 mol kg^{-1} (d) 0.44 mol kg^{-1}

13 A 15.00 mL sample of a solution is 0.04 M in Sn^{2+} and x M in Fe^{2+}. Both are easily oxidised by $Cr_2O_7^{2-}$ in acidic solution to Sn^{4+} and Fe^{3+} and itself reduced to Cr^{3+}. 18.0 mL of 0.125 M $Cr_2O_7^{2-}$ is required. Thus, x is

(a) 0.410 (b) 0.205
(c) 0.820 (d) 1.640

14 A mixture contains $Na_2C_2O_4$ and KHC_2O_4 in 1 : 1 molar ratio. Mixture is neutralised by 100 mL of 0.01 M KOH. What volume of 0.01 M $KMnO_4$? Thus, the same mixture is oxidised by

(a) 200 mL (b) 100 mL
(c) 90 mL (d) 80 mL

15 Weight of 1 L milk is 1.032 kg. It contains butter fat (density 865 kg m^{-3}) to the extent of 4% by volume/volume. The density of the fat free skimmed milk will be

(a) 1038.5 kg m^{-3} (b) 1032.2 kg m^{-3}
(c) 997 kg m^{-3} (d) 1000.5 kg m^{-3}

ANSWERS

SESSION 1

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

SESSION 2

1 (a)	**2** (c)	**3** (a)	**4** (b)	**5** (c)	**6** (b)	**7** (b)	**8** (c)	**9** (d)	**10** (c)
11 (b)	**12** (c)	**13** (c)	**14** (d)	**15** (a)					

Hints and Explanations

SESSION 1

1 $4.523 + 2.3 + 6.24 = 13.063$. As 2.3 has least number of decimal places, i.e. one, therefore sum should be reported to one decimal place only. After rounding off, reported sum = 13.1 which has three significant figures.

2 Average value $= \frac{25.2 + 25.25 + 25.0}{3} = \frac{75.45}{3} = 25.15 = 25.2$ mol

Number of significant figure is 3.

3 In metal oxide, metal = 53%, O = 47%

In CO_2, C = 27%, O = 73%

$\because$ 73 parts of oxygen combines with 27 parts of carbon.

$\therefore$ 47 parts of oxygen will combine $= \frac{27}{73} \times 47 = 17.38$ parts of C.

Thus, metal and carbon will be present in the ratio of 53 : 17.38. Hence, % of metal

$$= \frac{53}{53 + 17.38} \times 100 = 75.3\% \approx 75\%$$

4 First oxide is M_2O_3. Here, O is 31.6% and M is 68.4%.

Let second oxide be M_2O_x. Here, O is 48% and M is 52%.

So, 68.4g of M in first oxide

= 2 atom of M and 52 g of M contains

$= \frac{2 \times 52}{68.4} = 1.5$ atom of M and 52 g of M contains

31.6 g of oxygen in first oxide contains 3 atom of oxygen.

48 g of oxygen contains $= \frac{3 \times 48}{31.6} = 4.5$ atoms of oxygen

Ratio of M:O = 1.5 : 4.5 = 1 : 3

Thus, the formula is MO_3

5 H_3PO_2 disproportionates as

$$2H_3\overset{+1}{P}O_2 \longrightarrow \overset{-3}{P}H_3 + H_3\overset{+5}{P}O_4$$

Molecular wt. of $H_3PO_2 = 3 + 31 + 32 = 66$

$\therefore$ Eq. wt. $= \frac{66}{4} + \frac{66}{4} = 33$

6 $\frac{\text{Wt. of metal oxide}}{\text{Wt. of metal chloride}} = \frac{\text{Eq. wt. of metal + eq. wt. of oxide}}{\text{Eq. wt.of metal + eq. wt. of chloride}}$

$$\frac{3}{5} = \frac{E + 8}{E + 35.5}$$

where, [E = Eq. wt. of metal]

or $5E + 40 = 3E + 106.5$ or $2E = 66.5$

$\therefore$ $E = 33.25$

7 $2Br^- \longrightarrow Br_2$

Equivalents of Br^- = Equivalents of Br_2

$$\frac{w}{80} = \frac{10^3}{160/2}$$

$$w_{Br^-} = 10^3 \text{ g}$$

$\therefore$ Sea water needed $= \frac{10^3}{65 \times 10^{-3}} = 15.38 \times 10^3$ L

8 0.376 g Al = 0.468 L H_2

$\frac{0.376}{9}$ equivalent of Al = 0.468 L H_2

$\therefore$ 1 equivalent of Al = 11.2 L H_2

9 0.20 g oxygen ≡ 3.17 g halogen

$\therefore$ Equivalent mass halogen

$\equiv \frac{3.17}{0.20} \times 8 = 126.8 \text{ g} \simeq 127 \text{ g}$

10 Mass of the given amount of a substance is a constant quantity.

11 In $Mg_3(PO_4)_2$; 1 moles of O-atoms are present in 1 mole of $Mg_3(PO_4)_2$.

Hence, 0.25 mole of O-atom are contained

$= \frac{1}{8} \times 0.25$

$= 3.125 \times 10^{-2}$

12 I. 1 molecule of $O_2 = \frac{32}{6.022 \times 10^{23}}$ g

$= 5.3 \times 10^{-23}$ g

II. 1 atom of N $= \frac{14}{6.022 \times 10^{23}}$g

$= 2.3 \times 10^{-23}$ g

III. 10^{-10} g mol. wt. of oxygen

$= 10^{-10} \times 32 = 3.2 \times 10^{-9}$g

IV. 10^{-10}g atomic weight of copper

$= 10^{-10} \times 63.5 = 6.35 \times 10^{-9}$ g

$\therefore$ Order of increasing mass is

II < I < III < IV.

13 Number of atoms

$= \frac{\text{weight}}{\text{atomic weight}} \times N_A \times \text{species}$

$\therefore$ In 4 g of hydrogen,

Number of atoms $= \frac{4}{2} \times N_A \times 2 = 4N_A$

[Here, species = 2, because hydrogen is present as H_2]

In 71 g of chlorine,

Number of atoms $= \frac{71}{71} \times N_A \times 2 = 2\ N_A$

In 127 g of iodine,

Number of atoms $= \frac{127}{127} \times N_A \times 2$

$= 2N_A$

In 48 g of magnesium,

Number of atoms $= \frac{48}{24} \times N_A \times 1 = 2N_A$

[Here, Mg is present as Mg so species = 1] Thus, the number of atoms are largest in 4 g of hydrogen.

14 18 mL H_2O = 18 g H_2O = 1 mol

$= 6.02 \times 10^{23}$ molecules/atoms

In 1 atom of water 10 electrons are present.

$\therefore$ electrons in 1 mole H_2O

$= (2 + 8) \times 6.023 \times 10^{23}$ electrons

$= 10 \times 6.02 \times 10^{23}$

$= 6.02 \times 10^{24}$ electrons

15 $\because 6.02 \times 10^{23}$ molecules of $CuSO_4 \cdot 5H_2O$

$= 63.5 + 32 + 64 + 90 = 249.5$ g

$\therefore 1 \times 10^{22}$ molecules of $CuSO_4 \cdot 5H_2O$

$= \frac{249.5}{6.02 \times 10^{23}} \times 10^{22} = 4.15$ g

16 Number of moles of Fe

$= \frac{0.0056}{56} = 10^{-4}$ mol

2 moles of Fe is present in 1 mole of $(NH_4)_2SO_4Fe_2(SO_4)_3$.

Therefore, 10^{-4} mole of Fe is present in

$= \frac{10^{-4} \times 1}{2}$ mol

$= 0.5 \times 10^{-4}$ mol

17. 200 mg CO_2 = 0.2 g $= \frac{0.2}{44}$ mol

$= 0.00454$ mol $= 4.54 \times 10^{-3}$mol

10^{21} molecules of $CO_2 = \frac{10^{21}}{6.02 \times 10^{23}}$

$= 1.66 \times 10^{-3}$ mol

$\therefore$ Number of moles left

$= (4.54 - 1.66)\ 10^{-3}$

$= 2.88 \times 10^{-3}$

18 0.1 L = 100 mL has Pb = 30 mg

$= 30 \times 10^{-6}$ g

$= \frac{30 \times 10^{-6}}{207}$ mole of Pb

$= \frac{30 \times 10^{-6}}{207} \times 6.02 \times 10^{23}$ Pb atoms

Number of atoms per cm^3 blood

$= \frac{30 \times 10^{-6} \times 6.02 \times 10^{23}}{207 \times 100} = 8.72 \times 10^{14}$

19 16 g of $O_2 = \frac{16}{32} = 0.5$ mol

$= \frac{N_A}{2}$ molecules

14 g of $N_2 = \frac{14}{28} = 0.5$ mol

$= \frac{N_A}{2}$ molecules

20 Moles of sucrose $[C_{12}H_{22}O_{11}]$

$= \frac{25.6}{342.3} = 0.0747$

Number of H-atoms in 1 mole of sucrose

$= 22 \times 6.023 \times 10^{23}$

Number of H-atoms in 0.0747 mole of sucrose

$= 22 \times 6.023 \times 10^{23} \times 0.0747$

$= 9.9 \times 10^{23}$

21 Given, abundance of elements by mass oxygen = 61.4%, carbon = 22.9%, hydrogen = 10%

Total weight of person = 75 kg

Mass due to $^1H = \frac{75 \times 10 \times 1}{100} = 7.5$ kg

^1H atoms are replaced by ^2H atoms.

Mass due to $^2H = (7.5 \times 2)$ kg

$\therefore$ Mass gain by person = 7.5 kg

22 18 g H_2O contains 2 g of H

$\therefore$ 0.72 g H_2O contains 0.08 g of H.

44 g CO_2 contains 12 g of C

$\therefore$ 3.08 g CO_2 contains 0.84 g of C

$\therefore$ C : H $= \frac{0.84}{12} : \frac{0.08}{1} = 0.07 : 0.08 = 7 : 8$

$\therefore$ Empirical formula = C_7H_8

23 Weight of oxygen in sample

$= 0.2075 - 0.1475 = 0.06$ g

Moles of cobalt $= \frac{0.1475}{59} = 0.0025$

Moles of oxygen $= \frac{0.06}{16} = 0.0037$

Simplest ratio of Co $= \frac{0.0025}{0.0025} = 1.0$

Simplest ratio of O $= \frac{0.0037}{0.0025} = 1.48 \approx 1.5$

Ratio of Co:O = 1:1.5 = 2 : 3

So, the formula is Co_2O_3.

24 $\underset{15}{C_xH_y} + \underset{15(x+y)_4}{(x + y)_4 O_2} \longrightarrow \underset{15x}{xCO_2(g)} + y_2H_2O(l)$

Before Combustion

O_2 used = 20% of 375 = 75 mL

After Combustion

Inert part of air = 80% of 375 = 300 mL

Total volume of gases = CO_2 + Inert part of air

$330 = 15x + 300 \Rightarrow x = 2$

$\frac{x + (y/4)}{1} = \frac{75}{15} \Rightarrow x + \frac{y}{4} = 5$

$\Rightarrow x = 2,\ y = 12 \quad \Rightarrow C_2H_{12}$ or C_3H_6.

Thus empirical formula of compound is C_3H_6

25 We can calculate the simplest whole number ratio for C and H from the data given as:

Element	Relative mass	Molar mass	Relative mole	Simplest whole number ratio
C	6	12	$\frac{6}{12} = 0.5$	$\frac{0.5}{0.5} = 1$
H	1	1	$\frac{1}{1} = 1$	$\frac{1}{0.5} = 2$

Now, after calculating this ratio look for condition 2 given in the question, i.e. quantity of oxygen is half of the quantity required to burn one molecule of compound C_xH_y completely to CO_2 and H_2O. We can calculate number of oxygen atoms from this as consider the equation.

$$C_xH_y + \left[x + \frac{y}{4}\right]O_2 \longrightarrow xCO_2 + \frac{y}{2}H_2O$$

Number of oxygen atoms required

$$= 2 \times \left[x + \frac{y}{4}\right] = \left[2x + \frac{y}{2}\right]$$

Now given, $z = \frac{1}{2}\left[2x + \frac{y}{2}\right] = \left[2x + \frac{2}{4}\right]$

Here, we consider x and y as simplest ratios for C and H so, now putting the values of x and y in the above equation.

$$z = \left[x + \frac{y}{4}\right] = \left[1 + \frac{2}{4}\right] = 1.5$$

Thus, the simplest ratio figures for x, y and z are $x = 1$, $y = 2$ and $z = 1.5$.

Now, put these values in the formula given, i.e. $C_xH_yO_z = C_1H_2O_{1.5}$

So,empirical formula will be

$$[C_1H_2O_{1.5}] \times 2 = C_2H_4O_3$$

26 Let wt. of FeO $= a$ g and wt. of $Fe_3O_4 = b$ g

$$2FeO + \frac{1}{2}O_2 \longrightarrow Fe_2O_3$$

$$2Fe_3O_4 + \frac{1}{2}O_2 \longrightarrow 3Fe_2O_3$$

$\because$ 144 g of FeO gives 160 g Fe_2O_3.

$\therefore$ a g FeO will give $= \frac{160 \times a}{144}$ g Fe_2O_3

Similarly, weight of Fe_2O_3 formed by b g

$$Fe_3O_4 = \frac{160 \times 3 \times b}{464}$$

Now, if $a + b = 100$ ...(i)

Then, $\frac{160 \times a}{144} + \frac{160 \times 3 \times b}{464} = 105$ ...(ii)

From Eqs. (i) and (ii), $a = 20.25$ g

and $b = 79.75$ g

$\therefore$ Percentage of $Fe_3O_4 = 79.75\%$

27 The reaction is

$$2Ag^+ + CrO_4^{2-} \longrightarrow Ag_2CrO_4.$$

Using the limiting reagent concept, number of moles of Ag_2CrO_4

$$= 0.5 \times 10^{-3}$$

Amount of Ag_2CrO_4 formed

$$= 0.5 \times 10^{-3} \times 331.73$$
$$= 0.166 \text{ g}$$

28 Mixture X will contain 0.02 mole of Br^- ions and 0.02 mole of SO_4^{2-} ions in 2 L solution. Hence, 1 L of mixture X will contain 0.01 mole of Br^- and 0.01 SO_4^{2-} ions. With excess of $AgNO_3$, 0.01 moles of AgBr, i.e. Y is formed and with excess of $BaCl_2$, 0.01 moles of $BaSO_4$, i.e. Z is formed.

29 200 mL of 5 N HCl

$$= 200 \times 5 \text{ milliequivalents}$$
$$= 1000 \text{ millimoles} = 1 \text{ mol HCl}$$

1.7g of $AgNO_3$ = 0.01 mol

$AgNO_3$ +	HCl ⟶	AgCl + HNO_3
1 mol	1 mol	1 mol
0.01 mol	1 mol	0.01 mol

$AgNO_3$ is the limiting reagent.

Thus, AgCl formed = 0.01 mol

$$= 0.01 \times 143.5 = 1.435 \text{ g}$$

30 $3BaCl_2 + 2Na_3PO_4 \longrightarrow Ba_3(PO_4)_2 + 6NaCl$

Here, limiting reactant is Na_3PO_4.

0.2 mole of Na_3PO_4 will give $Ba_3(PO_4)_2$

$$= \frac{1}{2} \times 0.2 = 0.1 \text{ mol}$$

31 $2y \longrightarrow 2y^{3+} + 6e^-$ $[y \rightarrow y^{3+} + 3e^-]$

$6H^+ + 6e^- \longrightarrow 3H_2$ $[2H^+ + 2e^- \rightarrow H_2]$

$2y + 6H^+ \longrightarrow 2y^{3+} + 3H_2$

The above individual equations suggest that,

1 eq. of y = 1 eq. of H_2
$(n = 3)$ $(n = 2)$

$\Rightarrow$ $\frac{1}{3}$ mol $y = \frac{1}{2}$ mol H_2

Thus, $H_2 : y = 2 : 3$

32 Initial strength of acetic acid = 0.06 N

Final strength = 0.042 N

Given volume = 50 mL

$\therefore$ Initial millimoles of CH_3COOH

$$= 0.06 \times 50 = 3$$

Final millimoles of CH_3COOH

$$= 0.042 \times 50 = 2.1$$

$\therefore$ Millimoles of CH_3COOH adsorbed

$$= 3 - 2.1 = 0.9 \text{ mmol}$$

Hence, mass of CH_3COOH adsorbed per gram of charcoal $= \frac{0.9 \times 60}{3}$ [molar mass of $CH_3COOH = 60 \text{g mol}^{-1}$]

$$= \frac{54}{3} = 18 \text{ mg}$$

33 Molecular weight of $C_8H_7SO_3Na$

$= (12 \times 8) + (1 \times 7) + 32 + (3 \times 16) + 23$

$= 206$u

Number of moles in 206 g of $C_8H_7SO_3$ Na resin $= \frac{1}{206}$ mol

Now, reaction would be

$$2C_8H_7SO_3Na + Ca^{2+} \longrightarrow (C_8H_7SO_3)_2Ca + 2Na^+$$

$\therefore$ 2 moles of $C_8H_7SO_3Na$ combines with 1 mole of Ca^{2+}.

$\therefore$ 1 mole of $C_8H_7SO_3Na$ combines with $\frac{1}{2}$ mole of Ca^{2+}.

$\therefore \frac{1}{206}$ mole of $C_8H_7SO_3Na$ will combine with $\frac{1}{2} \times \frac{1}{206}$ mole of Ca^{2+}

$$= \frac{1}{412} \text{ mole of } Ca^{2+}$$

34 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 $Fe^{2+} = 750 \times 0.6$

$$= 450 \text{ mmol}$$

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

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

$\therefore$ 0.450 mole of $Fe^{2+} \equiv \frac{0.450}{6}$

$$= 0.0075 \text{ mole of } Cr_2O_7^{2-}$$

Mass of $K_2Cr_2O_7$ required

$$= 0.075 \times 294 \text{ g} = 22.05 \text{ g}$$

35 Normality equation is,

$$N_1V_1 + N_2V_2 + N_3V_3 = N_4(V_1 + V_2 + V_3)$$

or $1 \times 5 + 20 \times \frac{1}{2} + 30 \times \frac{1}{3} = N_4(5 + 20 + 30)$

$\therefore$ Resulting normality $(N_4) = \frac{25}{55} = 0.45$ N

36 For I solution : millimoles

$$= MV = 480 \times 1.5 = 720$$

For II solution : millimoles

$$= MV = 520 \times 1.2 = 624$$

Total millimoles = 720 + 624 = 1344

$\therefore$ Molarity $= \frac{\text{Moles of solute}}{\text{Total volume of solution (L)}}$

$$= \frac{1344}{480 + 520}$$
$$= 1.344 \text{ M}$$

37 Assertion and Reason both are false. As volume of solution changes by 20%, so it becomes $= 1 + \frac{20}{100} = 1.2$ L

$\therefore$ Molarity of resulting solution

$$= \frac{\text{Moles of solute}}{\text{Total volume of solution (L)}}$$
$$= 0.8 \text{ M}$$

and change in molarity = 1 − 0.8 = 0.2 M

$\therefore$ % change in molarity

$$= \frac{0.2}{1.2} \times 100 = 16.66\%$$

38 Both Assertion and Reason are false.

$$\underset{30\text{ mL}}{H_2} + \underset{15\text{ mL}}{\frac{1}{2}O_2} \rightarrow H_2O$$

Volume of O_2 left = 20 – 15 mL = 5 mL

Therefore, no H_2 left after the reaction hence, H_2 is the limiting reagent.

SESSION 2

1 $\underset{\substack{6\text{ g}\\450\text{ g}}}{N_2 + 3H_2} \longrightarrow \underset{\substack{2\times 17\text{ g}\\ \frac{34}{6}\times 450 = 2550\text{ g}}}{2NH_3}$

Actual = 1575 g

% yield = $\frac{1575 \times 100}{2550}$ = 61.76%

2 $(NH_4)_3PO_4$ has 12 H atoms and 4 O atoms; H:O = 3:1

Hence, O relative to 3.18 mol H = 1.06 mol

3 $2KClO_3 \longrightarrow 2KCl + 3O_2$

$4Al + 3O_2 \longrightarrow 2Al_2O_3$

2 mol of $KClO_3 \equiv$ 2 mol Al_2O_3

$\therefore$ 1 mol $KClO_3 \equiv$ 1 mol Al_2O_3

4 10^6 g solution = 1 g Fe^{2+}

250 mL = 250 g solution

$= \frac{1}{10^6} \times 250$ g Fe^{2+}

$= \frac{250 \times 392}{10^6 \times 56}$ g (*A*)

$= 1.75 \times 10^{-3}$

5 Number of millimoles of $Ca(OH)_2$

$= 50 \times 0.5 = 25$

Number of millimoles of $CaCO_3$ = 25

Number of milliequivalents of $CaCO_3$ = 50

$\therefore$ Volume of 0.1 N HCl

$= \frac{50}{0.1} = 500\ cm^3$

6 Required equation is given below:

$Zn + 2OH^- \longrightarrow ZnO_2^{2-} + 2H^+ + 2e^-$

$NO_3^- + 8H^+ + 8e^- \longrightarrow OH^- + 2H_2O + NH_3$

From the above equation,

$\because$ 8 mole of electrons are absorbed by 85 g of $NaNO_3$

$\therefore$ 1 mole of electron will be absorbed by $\frac{85}{8}$ g of $NaNO_3$ = 10.625g

7 $\underset{1\text{ mol}}{N_2} + \underset{4\text{ mol}}{3H_2} \longrightarrow 2NH_3$

$\underset{1}{NH_3} + \underset{1}{HCl} \longrightarrow NH_4Cl$

NH_3 formed = 1 mol

N_2 reacted = 0.5 mol

$\therefore$ H_2 reacted = 1.5 mol

N_2 unreacted = 1 – 0.5 = 0.5 mol

H_2 unreacted = 4 – 1.5 = 2.5 mol

NH_3 formed = 1 mol

But NH_3 gets dissolved in H_2O leaving N_2 and H_2

$\therefore \quad x_{H_2} = \frac{2.5}{3.0} = \frac{5}{6}$

8 K_2SO_4 is isomorphous with K_2SeO_4.

The molar weight of K_2SeO_4 is given by

$(2 \times 39) + x + (4 \times 16)$

[$\because$ x = atomic wt. of Se]

$\Rightarrow (142 + x)$ g

If $(142 + x)$g of K_2SeO_4 contains x g of K_2SO_4. So, therefore,

100 g of $K_2SeO_4 = \frac{x}{(142 + x)} \times 100$

But K_2SeO_4 contains 50% of Se, thus

$50 = \frac{x}{(142 + x)} \times 100$

or $\quad x = 142$ g

Hence, the atomic wt. of Se is 142 g.

9 $KMnO_4$ reacts with oxalic acid according to the following equation.

$2MnO_4^- + 5C_2O_4^{2-} + 16H^+ \longrightarrow 2Mn^{2+} + 10CO_2 + 8H_2O$

Equivalent mass of $KMnO_4$

$= \frac{\text{molecular mass}}{(7-2)}$

$N_{KMnO_4} = 5 \times \text{molarity} = 5 \times 10^{-4}$

Equivalent mass of

$C_2O_4^{2-} = \frac{\text{molecular mass}}{2(4-3)}$

$C_2O_4^{2-} = \frac{\text{molecular mass}}{2}$

$N_{C_2O_4^{2-}} = 2 \times \text{molarity}$

$= 2 \times 10^{-2}$

According to normality equation,

$N_1V_1 = N_2V_2$

$5 \times 10^{-4} \times V_1 = 2 \times 10^{-2} \times 0.5$

$V_1 = \frac{2 \times 10^{-2} \times 0.5}{5 \times 10^{-4}} = 20$ L

10 100 g haemoglobin contains 0.33 g Fe.

$\therefore$ 67200 g haemoglobin contains

$= \frac{0.33 \times 67200}{100}$ g Fe

= 221.76 g Fe

$\therefore$ Number of Fe-ato $= \frac{221.76}{56}$

$= 3.96 \approx 4$

11 $2BCl_3 + \frac{3}{2}H_2 \longrightarrow B + 3HCl$

No. of moles of elemental boron

$= \frac{21.6}{10.8} = 2$ mol

$\therefore$ No. of moles of H_2 consumed

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

Volume of H_2 at NTP = (22.4 × 3) L

= 67.2 L

12 Molarity of acetic acid = 2.05 M

Mass of CH_3COOH in 1 L solution

$= 2.05 \times 60 = 123$ g

Mass of 1 L solution = 1000 × 1.02 = 1020 g

(since density = 1.02 g/mL)

Mass of water in solution

= 1020 – 123 = 897 g

$\therefore$ Molality $= \frac{2.05}{897 \times 10^{-3}} = 2.28$ mol kg^{-1}

13

$Sn^{2+} \longrightarrow Sn^{4+} + 2e^-$ 2 units

$Fe^{2+} \longrightarrow Fe^{3+} + e^-$ 1 unit

$Cr_2O_7^{2-} + 6e^- \longrightarrow 2Cr^{3+}$ 6 units

Milliequivalent of $Sn^{2+} = 15 \times 0.04 \times 2 = 1.2$

Milliequivalent of $Fe^{2+} = 15x \times 1 = 15x$

Milliequivalent of $Cr_2O_7^{2-} = 18 \times 0.125 \times 6$

= 13.5

$\therefore \quad 1.2 + 15x = 13.5 \Rightarrow x = 0.82$

14 $KHC_2O_4 \equiv KOH$

100 mL of 0.01 M KOH

$\equiv$ 100 mL of 0.01 M KHC_2O_4

= 1 millimol KHC_2O_4

$\therefore$ $Na_2C_2O_4$ = 1 millimol

Total $C_2O_4^{2-}$ = 2 millimol

= 4 milliequiv

Let volume of $KMnO_4$ = *V* mL

(MnO_4^- reduced to Mn^{2+})

$\therefore \quad V \times 0.01 \times 5 = 4$

$\Rightarrow \quad V = 80$ mL

15 Let 100 m^3 milk contains 4 m^3 fat.

$\therefore$ Weight of butter fat in 1 m^3 milk

$= \frac{4}{100} \times 865 = 35$ kg

Weight of $10^3\ cm^3$ (1 L) milk = 1.032 kg

$\therefore$ Wt. of $10^6\ cm^3$ (1 m^3) milk = 1032 kg

$\therefore$ Weight of skimmed milk = 1032 – 35

= 997 kg

and volume of skimmed milk = 1 – 0.04

= 0.96 m^3

$\therefore$ Density of fat free skimmed milk

$= \frac{997}{0.96} = 1038.5$ kg m^{-3}