SOME BASIC CONCEPTS OF CHEMISTRY

Table of Contents

THEORY

1. CHEMISTRY

Chemistry is defined as the study of the composition, properties and interaction of matter. Chemistry is often called the central science because of its role in connecting the physical sciences, which include chemistry, with the life sciences and applied sciences such as medicine and engineering.

Various branches of chemistry are

1.1 Physical chemistry

The branch of chemistry concerned with the way in which the physical properties of substances depend on and influence their chemical structure, properties, and reactions.

1.2 Inorganic chemistry

The branch of chemistry which deals with the structure, composition and behavior of inorganic compounds. All the substances other than the carbon-hydrogen compounds are classified under the group of inorganic substances.

1.3 Organic chemistry

The discipline which deals with the study of the structure, composition and the chemical properties of organic compounds is known as organic chemistry.

1.4 Biochemistry

The discipline which deals with the structure and behavior of the components of cells and the chemical processes in living beings is known as biochemistry.

1.5 Analytical chemistry

The branch of chemistry dealing with separation, identification and quantitative determination of the compositions of different substances.

2. MATTER

Matter is defined as any thing that occupies space possesses mass and the presence of which can be felt by any one or more of our five senses.

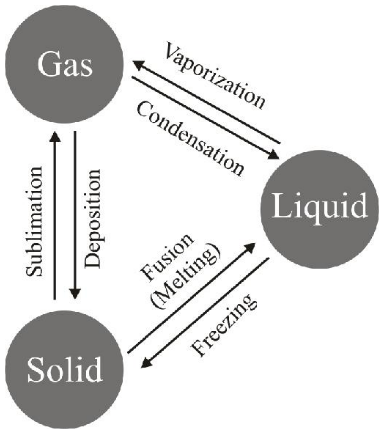
Matter can exist in 3 physical states viz. solid, liquid, gas.

Solid - a substance is said to be solid if it possesses a definite volume and a definite shape, e.g., sugar, iron, gold, wood etc.

Liquid- A substance is said to be liquid, if it possesses a definite volume but no definite shape. They take up the shape of the vessel in which they are put, e.g., water, milk, oil, mercury, alcohol etc.

Gas- a substance is said to be gaseous if it neither possesses definite volume nor a definite shape. This is because they fill up the whole vessel in which they are put, e.g., hydrogen, oxygen etc.

The three states are interconvertible by changing the conditions of temperature and pressure as follows

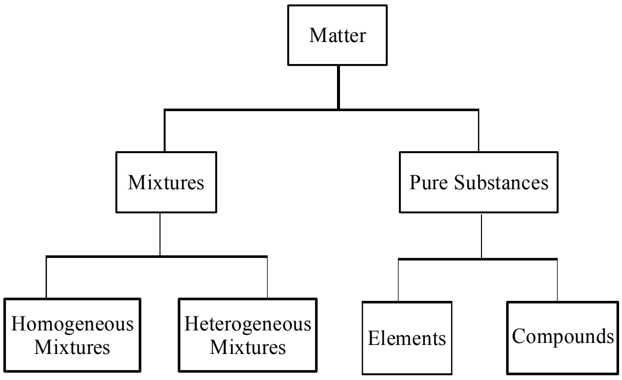


3. CLASSIFICATION OF MATTER AT MACROSCOPIC LEVELL

At the macroscopic or bulk level, matter can be classified as

(a) mixtures (b) pure substances.

These can be further sub-divided as shown below



Classification of matter

(a) **Mixtures :** A mixture contains two or more substances present in it (in any ratio) which are called its components. A mixture may be homogeneous or heterogeneous.

Homogeneous mixture- in homogeneous mixture the components completely mix with each other and its composition is uniform throughout i.e it consist of only one phase. Sugar solution and air are thus, the examples of homogeneous mixtures.

Heterogeneous mixtures- In heterogeneous mixture the composition is not uniform throughout and sometimes the different phases can be observed. For example, grains and pulses along with some dirt (often stone) pieces, are heterogeneous mixtures.

Note..

Any distinct portion of matter that is uniform throughout in composition and properties is called a **Phase**.

(b) **Pure substances :-** A material containing only one substance is called a pure substance.

Note..

In chemistry, a **substance** is a form of matter that has constant chemical composition and characteristic properties. It cannot be separated into components by physical separation methods, i.e. without breaking chemical bonds. They can be solids, liquids or gases.

Pure substances can be further classified into **elements** and **compounds.**

Element- An element is defined as a pure substance that contains only one kind of particles. Depending upon the physical and chemical properties, the elements are further subdivided into three classes, namely (1) Metals (2) Non-metals and (3) Metalloids.

Compound- A compound is a pure substance containing two or more than two elements combined together in a fixed proportion by mass. Further, the properties of a compound are completely different from those of its constituent elements. Moreover, the constituents of a compound cannot be separated into simpler substances by physical methods. They can be separated by chemical methods.

4. PROPERTIES OF MATTER

Every substance has unique or characteristic properties. These properties can be classified into two categories – physical properties and chemical properties.

4.1 Physical Properties

Physical properties are those properties which can be measured or observed without changing the identity or the composition of the substance. Some examples of physical properties are color, odor, melting point, boiling point, density etc.

4.2 Chemical properties

Chemical properties are those in which a chemical change in the substance occurs. The examples of chemical properties are characteristic reactions of different substances; these include acidity or basicity, combustibility etc.

5. MEASUREMENT

5.1 Physical quantities

All such quantities which we come across during our scientific studies are called Physical quantities. Evidently, the measurement of any physical quantity consists of two parts

(1) The number, and (2) The unit

A **unit** is defined as the standard of reference chosen to measure any physical quantity.

5.2 S.I. UNITS

The International System of Units (in French Le Systeme International d'Unités – abbreviated as SI) was established by the 11th General Conference on Weights and Measures (CGPM from Conference Generale des Poids at Measures). The CGPM is an inter governmental treaty organization created by a diplomatic treaty known as Meter Convention which was signed in Paris in 1875.

The SI system has seven base units and they are listed in table given below.

These units pertain to the seven fundamental scientific quantities. The other physical quantities such as speed, volume, density etc. can be derived from these quantities. The definitions of the SI base units are given below :

Definitions of SI Base Units

Unit of length	**metre**	The metre is the length of the path travelled by light in vacuum during a time interval of 1/299 792 458 of a second.
Unit of mass	**Kilogram**	The kilogram is the unit of mass; it is equal to the mass of the internationl prototype of the kilogram.
Unit of time	**second**	The second is the duration of 9 192 631 770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the caesium-133 atom.
Unit of electric current	**ampere**	The ampere is that constant current which, if maintained in two straight parallel conductors of infinite length, of negligible circular cross-section, and placed 1 metre apart in vacuum, would produce between these conductors a force equal to 2×10^{-7} newton per metre of length.
Unit of thermodynamic temperature	**kelvin**	The kelvin, unit of thermodynamic temperature, is the fraction 1/273. 16 of the thermodynamic temperature of the triple point of water.
Unit of amount of substance	**mole**	1. The mole is the amount of substance of a system which contains as many elementary entities as there are atoms in 0.012 kilogram of carbon-12; its symbol is "mol.". 2. When the mole is used, the elementary entities must be specified and may be atoms, molecules, ions, electrons, other particles, or specified groups of such particles.
Unit of luminous intensity	**candela**	The candela is the luminous intensity, in a given direction, of a source that emits monochromatic radiation of frequency 540×10^{12} hertz and that has a radiant intensity in that direction of 1/683 watt per steradian.

Note..

The mass standard is the kilogram since 1889. It has been defined as the mass of platinum-iridium (Pt-Ir) cylinder that is stored in an airtight jar at International Bureau of Weights and Measures in Sevres, France. **Pt-Ir was chosen for this standard because it is highly resistant to chemical attack and its mass will not change for an extremely long time.**

6. SOME IMPORTANT DEFINITION

6.1 Mass and Weight

Mass of a substance is the amount of matter present in it while **weight** is the force exerted by gravity on an object. The mass of a substance is constant whereas its weight may vary from one place to another due to change in gravity. The **SI unit** of mass is the **kilogram** (kg). The **SI derived unit** (unit derived from SI base units) of weight is **newton**.

6.2 Volume

Volume is the quantity of three-dimensional space enclosed by some closed boundary, for example, the space that a substance (solid, liquid, gas, or plasma) or shape occupies or contains. Volume is often quantified numerically using the SI derived unit, the cubic meter.

6.3 Density

The **mass density** or **density** of a material is defined as its mass per unit volume. The symbol most often used for density is ρ (the lower case Greek letter rho). SI unit of density is kg m^{-3}.

6.4 Temperature

Temperature is a physical property of matter that quantitatively expresses the common notions of hot and cold. There are three common scales to measure temperature — °C (degree celsius), °F (degree fahrenheit) and K (kelvin). The temperature on two scales is related to each other by the following relationship:

$$°F = 9/5\,(°C) + 32$$

$$K = °C + 273.15$$

7. LAW OF CHEMICAL COMBINATION

7.1 Law of conservation of mass

"In a chemical reaction the mass of reactants consumed and mass of the products formed is same, that is mass is conserved." This is a direct consequence of law of conservation of atoms. This law was put forth by Antoine Lavoisier in 1789.

7.2 Law of Constant / Definite Proportions

The ratio in which two or more elements combine to form a compound remains fixed and is independent of the source of the compound. This law was given by, a French chemist, Joseph Proust.

7.3 Law of Multiple Proportions

When two elements combine to form two or more compounds then the ratio of masses of one element that combines with a fixed mass of the other element in the two compounds is a simple whole number ratio. This law was proposed by Dalton in 1803.

7.4 Law of Reciprocal Proportions

When three elements combine with each other in combination of two and form three compounds then the ratio of masses of two elements combining with fixed mass of the third and the ratio in which they combine with each other bear a simple whole number ratio to each other. This Law was given by **Richter** in 1792.

7.5 Gay Lussac's Law of Gaseous Volumes

This law was given by Gay Lussac in 1808. He observed 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.

7.6 Avogadro Law

In 1811, Avogadro proposed that equal volumes of gases at the same temperature and pressure should contain equal number of molecules.

8. DALTON'S ATOMIC THEORY

In 1808, Dalton published 'A New System of Chemical Philosophy' in which he proposed the following:

1. Matter consists of indivisible atoms.
2. All the atoms of a given element have identical properties including identical mass. Atoms of different elements differ in mass.
3. Compounds are formed when atoms of different elements combine in a fixed ratio.
4. Chemical reactions involve reorganization of atoms. These are neither created nor destroyed in a chemical reaction.

9. ATOM

Atom is the smallest part of an element that can participate in a chemical reaction. {**Note :** This definition holds true only for non-radioactive reactions}

9.1 Mass of an Atom

There are two ways to denote the mass of atoms.

9.2 Method 1

Atomic mass can be defined as a mass of a single atom which is measured in atomic mass unit (amu) or unified mass (u) where

1 a.m.u. = 1/12th of the mass of one C^{12} atom

9.3 Method 2

Mass of 6.022×10^{23} atoms of that element taken in grams. This is also known as molar atomic mass.

Note...

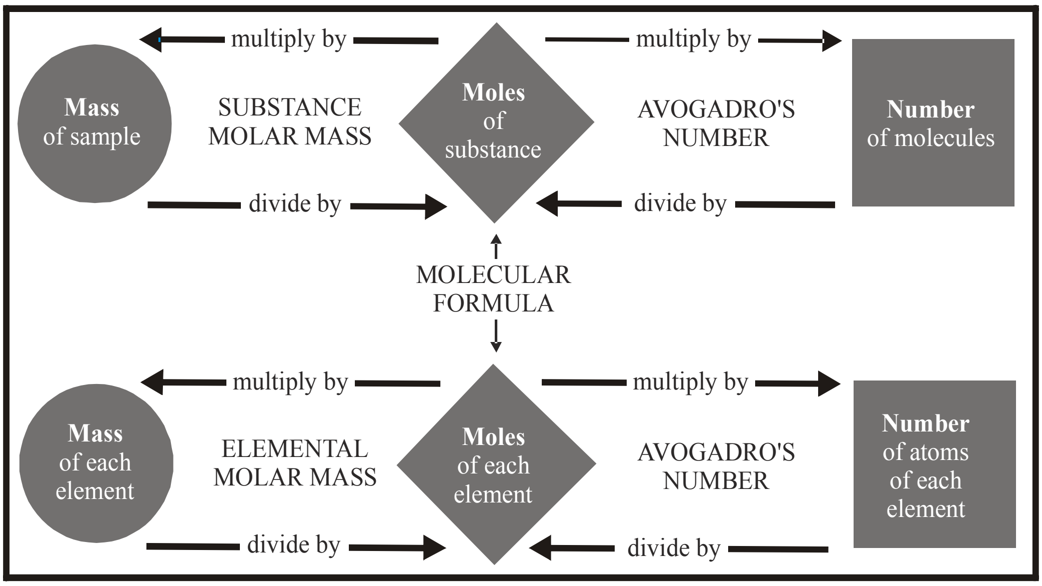
- Mass of 1 atom in amu and mass of 6.022×10^{23} atoms in grams are numerically equal.
- When atomic mass is taken in grams it is also called the molar atomic mass.
- 6.022×10^{23} is also called 1 mole of atoms and this number is also called the **Avogadro's Number.**
- Mole is just a number. As 1 dozen = 12;

  1 million = 10^6; 1 mole = 6.022×10^{23}.

10. MOLECULES

A group of similar or dissimilar atoms which exist together in nature is known as a molecule. e.g. H_2, NH_3.

The mass of molecules is measured by adding the masses of the atoms which constitute the molecule. Thus, the mass of a molecule can also be represented by the two methods used for measuring the mass of an atom viz. amu and g/mol.



11. CHEMICAL REACTIONS

A chemical reaction is only rearrangement of atoms. Atoms from different molecules (may be even same molecule) rearrange themselves to form new molecules.

Points to remember :

- Always balance chemical equations before doing any calculations
- The number of molecules in a reaction need not to be conserved e.g.

  $N_2 + 3\,H_2 \rightarrow 2\,NH_3$. The number of molecules is not conserved

  If we talk about only rearrangement of atoms in a balanced chemical reaction then it is evident that the mass of the atoms in the reactants side is equal to the sum of the masses of the atoms on the products side. This is the **Law of Conservation of Atoms** and **Law of Conservation of Mass.**

12. STOICHIOMETRY

The study of chemical reactions and calculations related to it is called Stoichiometry. The coefficients used to balance the reaction are called **Stoichiometric Coefficients.**

Points to remember :

- The stoichiometric coefficients give the ratio of molecules or moles that react and **not the ratio of masses.**
- Stoichiometric ratios can be used to predict the moles of product formed only if all the reactants are present in the stoichiometric ratios.

  Practically the amount of products formed is always less than the amount predicted by theoretical calculations

12.1 Limiting Reagent (LR) and Excess Reagent (ER)

If the reactants are not taken in the stoichiometric ratios then the reactant which is less than the required amount determines how much product will be formed and is known as the **Limiting Reagent** and the reactant present in excess is called the **Excess Reagent.** e.g. if we burn carbon in air (which has an infinite supply of oxygen) then the amount of CO_2 being produced will be governed by the amount of carbon taken. In this case, Carbon is the LR and O_2 is the ER.

13. PERCENT YIELD

As discussed earlier, due to practical reasons the amount of product formed by a chemical reaction is less than the amount predicted by theoretical calculations. The ratio of the amount of product formed to the amount predicted when multiplied by 100 gives the percentage yield.

$$\text{Percentage Yield} = \frac{\text{Actual Yield}}{\text{Theoretical Yield}} \times 100$$

14. REACTIONS IN AQUEOUS MEDIA

Two solids cannot react with each other in solid phase and hence need to be dissolved in a liquid. When a solute is dissolved in a solvent, they co-exist in a single phase called the solution. Various parameters are used to measure the strength of a solution.

The strength of a solution denotes the amount of solute which is contained in the solution. The parameters used to denote the strength of a solution are:

- **Mole fraction X :** moles of a component / Total moles of solution.
- **Mass% :** Mass of solute (in g) present in 100g of solution.
- **Mass/Vol :** Mass of solute (in g) present in 100mL of solution
- **v/v :** Volume of solute/volume of solution {only for liq-liq solutions}
- **g/L :** Wt. of solute (g) in 1L of solution
- **ppm :** $\frac{\text{mass of solute}}{\text{mass of solution}} \times 10^6$
- **Molarity (M) :** $\frac{\text{moles of solute}}{\text{volume of solution (L)}}$
- **Molality (m) :** $\frac{\text{moles of solute}}{\text{mass of solvent (kg)}}$

IMPORTANT RELATIONS

1. Relation between molality (m) Molarity (M), density (d) of solution and molar mass of solute (M_O)

   d : density in g/mL

   M_O : molar mass in g mol^{-1}

$$\text{Molality, } m = \frac{M \times 1000}{1000d - MM_O}$$

2. Relationship between molality (m) and mole fraction (X_B) of the solute

$$m = \frac{X_B}{1 - X_B} \times \frac{1000}{M_A} \qquad m = \frac{1 - X_A}{X_A} \times \frac{1000}{M_A}$$

Points to remember :

- Molarity is the most common unit of measuring strength of solution.
- The product of Molarity and Volume of the solution gives the number of moles of the solute, $n = M \times V$
- All the formulae of strength have amount of solute. (weight or moles) in the numerator.
- All the formulae have amount of solution in the denominator **except for molality (m).**

15. DILUTION LAW

When a solution is diluted, more solvent is added, the moles of solute remains unchanged. If the volume of a solution having a Molarity of M_1 is changed from V_1 to V_2 we can write that:

$$\mathbf{M_1V_1 = \text{moles of solute in the solution} = M_2V_2}$$

16. EFFECT OF TEMPERATURE

Volume of the solvent increases on increasing the temperature. But it shows **no effect on the mass of solute** in the solution assuming the system to be closed i.e. no loss of mass.

The formulae of strength of solutions which do not involve volume of solution are unaffected by changes in temperature. e.g. molality remains unchanged with temperature. Formulae involving volume are altered by temperature e.g. Molarity.

17. INTRODUCTION TO EQUIVALENT CONCEPT

Equivalent concept is a way of understanding reactions and processes in chemistry which are often made simple by the use of Equivalent concept.

17.1 Equivalent Mass

"The mass of an acid which furnishes 1 mol H^+ is called its Equivalent mass."

"The mass of the base which furnishes 1 mol OH^- is called its Equivalent mass."

17.2 Valency Factor (Z)

Valency factor is the number of H^+ ions supplied by 1 molecule or mole of an acid or the number of OH^- ions supplied by 1 molecule or 1 mole of the base.

$$\text{Equivalent mass, } E = \frac{\text{Molecular Mass}}{Z}$$

17.3 Equivalents

$$\textbf{No. of equivalents} = \frac{\text{wt. of acid / base taken}}{\text{Eq. wt.}}$$

Note..

It should be always remembered that 1 equivalent of an acid reacts with 1 equivalent of a base.

18. MIXTURE OF ACIDS AND BASES

Whenever we have a mixture of multiple acids and bases we can find whether the resultant solution would be acidic or basic by using the equivalent concept. For a mixture of multiple acids and bases find out the equivalents of acids and bases taken and find which one of them is in excess.

19. LAW OF CHEMICAL EQUIVALENCE

According to this law, one equivalent of a reactant combines with one equivalent of the other reactant to give one equivalent of each product . For, example in a reaction aA + bB $\rightarrow$ cC + dD irrespective of the stoichiometric coefficients, 1 eq. of A reacts with 1 eq. of B to give 1 eq. each of C and 1eq of D

20. EQUIVALENT WEIGHTS OF SALTS

To calculate the equivalent weights of compounds which are neither acids nor bases, we need to know the charge on the cation or the anion. The mass of the cation divided by the charge on it is called the equivalent mass of the cation and the mass of the anion divided by the charge on it is called the equivalent mass of the anion. When we add the equivalent masses of the anion and the cation, it gives us the equivalent mass of the salt. For salts, Z in the total amount of positive or negative charge furnished by 1 mol of the salt.

21. ORIGIN OF EQUIVALENT CONCEPT

Equivalent weight of an element was initially defined as **weight of an element which combines with 1g of hydrogen.** Later the definition wad modified to : **Equivalent weight of an element is that weight of the element which combines with 8g of Oxygen.**

Note...

Same element can have multiple equivalent weights depending upon the charge on it. e.g. Fe^{2+} and Fe^{3+}.

22. EQUIVALENT VOLUME OF GASES

Equivalent volume of gas is the volume occupied by 1 equivalent of a gas at STP.

Equivalent mass of gas = molecular mass /Z.

Since 1 mole of gas occupies 22.4L at STP therefore 1 equivalent of a gas will occupy 22.4/Z L at STP. e.g. Oxygen occupies 5.6L, Chlorine and Hydrogen occupy 11.2L.

23. NORMALITY

The normality of a solution is the number of equivalents of solute present in 1L of the solution.

$$N = \frac{\text{equivalents of solute}}{\text{volume of solution (L)}}$$

The number of equivalents of solute present in a solution is given by **Normality × Volume (L).**

On dilution of the solution the number of equivalents of the solute is conserved and thus, we can apply the formula : $N_1V_1 = N_2V_2$

Caution :

Please note that the above equation gives rise to a lot of confusion and is a common mistake that students make. This is the equation of dilution where the number of equivalents are conserved. Now, since one equivalent of a reactant always reacts with 1 equivalent of another reactant a similar equation is used in problems involving titration of acids and bases. Please do not extend the same logic to molarity.

Relationship between Normality and Molarity

N = M × Z ; where 'Z' is the Valency factor

SOLVED EXAMPLES

Example - 1

Classify the following substances into elements, compounds and mixtures.

(i) Air (ii) Diamond (iii) LPG (iv) Dry ice (v) Graphite (vi) Steel (vii) Marble (viii) Smoke (ix) Glucose (x) Laughing gas.

Sol.

Elements : Diamond; Graphite

Compounds : Marble; Glucose; Laughing gas; Dry ice

Mixtures : Air; LPG; Steel; Smoke

Example - 2

Classify the following mixtures as homogeneous and heterogeneous.

(i) Air (ii) Smoke (iii) Petrol (iv) Sea water (v) Iodized table salt (vi) Aerated water (vii) Mixture of sand and common salt (viii) Gun powder (ix) Milk (x) Muddy water.

Sol. **Homogeneous :** Air; Petrol; Iodized table salt; Sea water; Aerated water; Milk.

Heterogeneous : Smoke; Gun powder; Mixture of sand common salt; Muddy water.

Example - 3

Why Law of conservation of mass should better be called as Law of conservation of mass and energy ?

Sol. In nuclear reactions, it is observed that the mass of the products is less than the mass of the reactants. The difference of mass, called the mass defect, is converted into energy according to Einstein equation, $E = \Delta m c^2$. Hence, we better call it as a low of conservation of mass and energy.

Example - 4

If the speed of light is 3.0×10^8 m s^{-1}, calculate the distance covered by light in 2.00 ns.

Sol. Distance covered = Speed × Time = $3.0 \times 10^8 \text{m s}^{-1} \times 2.00 \text{ ns}$

$$= 3.0 \times 10^8 \text{m s}^{-1} \times 2.00 \text{ ns} \times \frac{10^{-9}\text{s}}{1 \text{ ns}} = 6.00 \times 10^{-1}\text{m}$$

$$\mathbf{= 0.600 \text{ m}}$$

Example - 5

What is the S.I. unit of mass ?

Sol. S.I. unit of mass is kilogram (kg).

Example - 6

In the reaction, $A + B_2 \rightarrow AB_2$, identify the limiting reagent, if any, in the following mixtures

(i) 300 atoms of A + 200 molecules B_2

(ii) 2 mol A + 3 mol B_2

(iii) 100 atoms of A + 100 molecules of B_2

(iv) 5 mol A + 2.5 mol B_2

(v) 2.5 mol A + 5 mol B_2

Sol. (i) According to the given reaction, 1 atom of A reacts with 1 molecule of B_2.

∴ 200 molecules of B_2 will react with 200 atoms of A and 100 atoms of A will be left unreacted. Hence, B_2 is the limiting reagent while A is the excess reagent.

(ii) According to the given reaction, 1 mol of A reacts with 1 mol of B_2. Hence A is limiting reagent.

(iii) No limiting reagent.

(iv) 2.5 mol of B_2 will react with 2.5 mol of A. Hence, B_2 is the limiting reagent.

(v) 2.5 mol of A will react with 2.5 mol of B_2. Hence, A is the limiting reagent.

Example - 7

Is the law of constant composition true for all types of compounds ? Explain why or why not.

Sol. No, law of constant composition is not true for all types of compounds. It is true only for the compounds obtained from one isotope. For example, carbon exists in two common isotopes, ^{12}C and ^{14}C.

Example - 8

Why atomic masses are the average values ?

Sol. Most of the elements exist in different isotopes, i.e., atoms with different masses, e.g., Cl has two isotopes with mass numbers 35 and 37 existing in the ratio 3 : 1 Hence, average value is taken.

Example - 9

What mass of sodium chloride would be decomposed by 9.8 g of sulphuric acid, if 12 g of sodium bisulphate and 2.75 g of hydrogen chloride were produced in a reaction assuming that the law of conservation of mass is true ?

Sol. $NaCl + H_2SO_4 = NaHSO_4 + HCl$

According to law of conservations of mass,

Total masses of reactants = Total masses of products

Let the mass of NaCl decomposed be x g; so

$x + 9.8 = 12.0 + 2.75$

$= 14.75$

$x =$ **4.95 g**

Example - 10

In an experiment, 2.4 g of iron oxide on reduction with hydrogen yield 1.68 g of iron. In another experiment 2.9 g of iron oxide given 2.03 g of iron on reduction with hydrogen. Show that the above data illustrate the law of constant proportions.

Sol. In the first experiment

The mass of iron oxide = 2.4 g

The mass of iron after reduction = 1.68 g

The mass of oxygen = Mass of iron oxide – Mass of iron

$= (2.4 - 1.68) = 0.72$ g

Ration of oxygen and iron = 0.72 : 1.68

= 1 : 2.33

In the second experiment

The mass of iron oxide = 2.9 g

The mass of iron after reduction = 2.03 g

The mass of oxygen = (2.9 – 2.03) = 0.87 g

Ratio of oxygen and iron = 0.87 : 2.03

= 1 : 2.33

Example - 11

Carbon and oxygen are known to form two compounds. The carbon content in one of these is 42.9% while in the other it is 27.3%. Show that this data is in agreement with the law of multiple proportions.

Sol.

Oxide 1	**Carbon**	**Oxygen**
	42.9%	57.1%

∴ Amount of oxygen that combines with 1 g carbon

$$= \frac{57.1}{42.9} = \mathbf{1.33\ g}$$

Oxide 1	**Carbon**	**Oxygen**
	27.3%	72.7%

∴ Amount of oxygen that combines with 1 g carbon

$$= \frac{72.7}{27.3} = \mathbf{2.66\ g}$$

Ratio of oxygen in oxide (1) and (2) = 1 : 2

Thus, Law of multiple proportion is verified.

Example - 12

In three moles of ethane (C_2H_6), calculate :

(i) Number of moles of carbon atoms

(ii) Number of moles of hydrogen atoms

(iii) Number of molecules of ethane

Sol. (i) 1 mole of C_2H_6 contains 2 moles of carbon atoms

∴ 3 moles of C_2H_6 will C-atoms = **6 moles**

(ii) 1 mole of C_2H_6 contains 6 moles of hydrogen atoms

∴ 3 moles of C_2H_6 will contain H-atoms **= 18 moles**

(iii) 1 mole of C_2H_6 contains Avogadro's no., i.e.,

6.02×10^{23} molecules

∴ 3 moles of C_2H_6 will contain ethane molecules

$= 3 \times 6.02 \times 10^{23}$

$= \mathbf{18.06 \times 10^{23}}$ **molecules**

Example - 13

Zinc sulphate crystals contain 22.6% of zinc and 43.9% of water. Assuming the law of constant proportions to be true, how much zinc should be used to produce 13.7 g of zinc sulphate and how much water will they contain ?

Sol. 100 g of zinc sulphate crystals are obtained from

= 22.6 g zinc

1 g of zinc sulphate crystals will be obtained from

= 22.6/100 g zinc

13.7 g of zinc sulphate crystals will be obtained from

$$= \frac{22.6}{100} \times 13.7 = 3.0962 \text{ g of zinc}$$

100 g of zinc sulphate crystals contain water = 43.9 g

1 g of zinc sulphate crystals contain water = 43.9/100 g

13.7 g of zinc sulphate crystals shall contain water

$$= \frac{43.9}{100} \times 13.7 = \mathbf{6.0143\ g}$$

Example - 14

What will be the mass of one ^{12}C atom in g ?

Sol. 1 mol of ^{12}C atoms = 6.022×10^{23} atoms = 12g

Thus, 6.022×10^{23} atoms of ^{12}C have mass = 12g

$\therefore$ 1 atom of ^{12}C will have mass = $\frac{12}{6.022 \times 10^{23}}$ g

$$= \mathbf{1.9927 \times 10^{-23}\ g}$$

Example - 15

Calculate the molecular mass of :

(i) H_2O (ii) CO_2 (iiii) CH_4

Sol. (i) Molecular mass of H_2O = 2 (1.008 amu) + 16.00 amu

= 18.016 amu

(ii) Molecular mass of CO_2 = 12.01 amu + 2 × 16.00 amu

= 44.01 amu

(iii) Molecular mass of CH_4 = 12.01 amu + 4 (1.008 amu)

= 16.042 amu

Example - 16

Calculate the mass per cent of different elements present in sodium sulphate (Na_2SO_4).

Sol. Mass % of an element

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

Now, molar mass of Na_2SO_4 = 2 (23.0) + 32.0 + 4 × 16.0

= 142 g mol^{-1}

Mass percent of sodium = $\frac{46}{142} \times 100$ **= 32.39 %**

Mass per cent of sulphur = $\frac{32}{142} \times 100$ **= 22.54 %**

Mass per cent of oxygen = $\frac{64}{142} \times 100$ **= 45.07%**

Example - 17

Calculate the amount of carbon dioxide that could be produced when

(i) 1 mole of carbon is burnt in air.

(ii) 1 mole of carbon is burnt in 16 g of dioxygen.

(iii) 2 moles of carbon are burnt in 16 g of dioxygen.

Sol. The balanced equation for the combustion of carbon in dioxygen/air is

$$\underset{\text{1 mole}}{C(s)} + \underset{\substack{\text{1 mole}\\(32\text{ g})}}{O_2(g)} \longrightarrow \underset{\substack{\text{1 mole}\\(44\text{ g})}}{CO_2(g)}$$

(i) In air, combustion is complete. Therefore, CO2 produced from the combustion of 1 mole of carbon = 44 g.

(ii) As only 16 g of dioxygen is available, it can combine only with 0.5 mole of carbon, i.e., dioxygen is the limiting reactant. Hence, CO_2 produced = **22 g.**

(iii) Here again, dioxygen is the limiting reactant. 16 g of dioxygen can combine only with 0.5 mole of carbon. CO_2 produced again is equal to 22 g.

Example - 18

Hydrogen chloride (HCl) on oxidation gives water and chlorine. How many litres of chlorine at STP can be obtained starting with 36.50 g HCl ?

Sol. Oxidation of HCl takes place according to the following equation :

$$\underset{4\text{ mol}}{4HCl} + O_2 \longrightarrow \underset{2\text{ mol}}{2Cl_2} + 2H_2O$$

$$\text{Moles of HCl} = \frac{\text{Mass}}{\text{Molecular mass}} = \frac{36.5}{36.5} = 1 \text{ mole}$$

$\because$ 4 moles HCl give 2 moles Cl_2

$\therefore$ 1 mole will give $\frac{2}{4}$ moles $Cl_2 = 0.5$ moles Cl_2

Volume of Cl_2 at STP = 22.4 × 0.5 = **11.2 litre**

Example - 19

Why is air sometimes considered as a heterogeneous mixture ?

Sol. This is due to the presence of dust particles which form a separate phase.

Example - 20

Calculate the mass of sodium acetate (CH_3COONa) required to make 500 mL of 0.375 molar aqueous solution. Molar mass of sodium acetate is 82.0245 g mol^{-1}.

Sol. 0.375 M aqueous solution means that 1000 mL of the solution contain sodium acetate = 0.375 mole

$\therefore$ 500 mL of the solution should contain sodium acetate

$$= \frac{0.375}{2} \text{ mole}$$

Molar mass of sodium acetate = 82.0245 g mol^{-1}

$\therefore$Mass of sodium acetate acquired

$$= \frac{0.375}{2} \text{ mole} \times 82.0245 \text{g mol}^{-1}$$

= 15.380 g.

Example - 21

Boron has two isotopes boron-10 and boron-11 whose percentage abundances are 19.6% and 80.4% respectively. What is the average atomic mass of boron ?

Sol. Average atomic mass of B =

$$\frac{(10\times19.6)+(11\times80.4)}{100} = \mathbf{10.804\ amu}$$

Example - 22

Carbon occurs in nature as a mixture of carbon-12 and carbon-13. The average atomic mass of carbon is 12.011. What is the percentage abundance of carbon-12 in nature ?

Sol. Let x be the percentage abundance of carbon-12; then (100 – x) will be the percentage abundance of carbon-13.

$$\text{Therefore, } \frac{12x + 13(100 - x)}{100} = 12.011$$

$$\text{or} \quad 12x + 1300 - 13x = 1201.1$$

$$x = 98.9$$

Abundance of carbon-12 is **98.9%**

Example - 23

Calculate the mass of 2.5 gram atoms of oxygen.

Sol. We know that

$$\text{Number of gram atoms} = \frac{\text{Mass of an element in grams}}{\text{Atomic mass of the element in grams}}$$

So, Mass of oxygen = 2.5 × 16 = **40.0 g**

Example - 24

Calculate the gram atoms in 2.3 g of sodium.

Sol. $\text{Number of gram atoms} = \frac{2.3}{23} = 0.1$

[Atomic mass of sodium = 23 g]

Example - 25

Calculate the mass of 1.5 gram molecule of sulphuric acid.

Sol. Molecular mass of H_2SO_4

$$= 2 \times 1 + 32 + 4 \times 16 = 98.0 \text{ amu}$$

Gram-molecular mass of $H_2SO_4 = 98.0$ g

Mass of 1.5 gram molecule of $H_2SO_4 = 98.0 \times 1.5 = \mathbf{147.0g}$

Example - 26

Calculate the actual mass of one molecule of carbon dioxide (CO_2).

Sol. Molecular mass of $CO_2 = 44$ amu

$$1 \text{ amu} = 1.66 \times 10^{-24} \text{ g}$$

So, the actual mass of $CO_2 = 44 \times 1.66 \times 10^{-24}$

$$= \mathbf{7.304 \times 10^{-23} g}$$

Example - 27

Calculate the mass of a single atom of sulphur and a single molecule of carbon dioxide.

Sol. Gram-atomic mass of sulphur = 32 g

$$\text{Mass of one sulphur atom} = \frac{\text{Gram} - \text{atomic mass}}{6.02 \times 10^{23}}$$

$$= \frac{32}{6.02 \times 10^{23}} = 5.31 \times 10^{-23} \text{ g}$$

Formula of carbon dioxide = CO_2

Molecular mass of $CO_2 = 12 + 2 \times 16 = 44$

Gram-molecular mass of $CO_2 = 44$ g

$$\text{Mass of one molecule of } CO_2 = \frac{\text{Gram} - \text{molecular mass}}{6.02 \times 10^{23}}$$

$$= \frac{44}{6.02 \times 10^{23}} = \mathbf{7.308 \times 10^{-23} \text{ g}}$$

Example - 28

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 ?

Sol. Molar mass of sugar ($C_{12}H_{22}O_{11}$) = $12 \times 12 + 22 \times 1 + 11 \times 16$

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

$$\text{No. of moles in 20 g of sugar} = \frac{20\text{g}}{342\text{g mol}^{-1}} = 0.0585 \text{ mole}$$

Volume of solution = 2 L (Given)

$$\text{Molar concentration} = \frac{\text{Moles of solute}}{\text{Volume of sol in L}} = \frac{0.0582 \text{ mol}}{2\text{L}}$$

$$= 0.0293 \text{ mol L}^{-1} = \mathbf{0.0293 \ M}$$

Example - 29

How many molecules of water and oxygen atoms are present in 0.9 g of water ?

Sol. **Given :**

Mass of water = 0.9 g

Molar mass of water = 18 g mol^{-1}

Number of molecules of water and number of oxygen atoms present in water are to be calculated.

To find :

$$\text{Number of moles, n} = \frac{\text{Mass}}{\text{Molar mass}}$$

Number of molecules = $n \times 6.02 \times 10^{23}$

Solution :

$$n = \frac{0.9}{18} = 0.05$$

Number of molecules of water = $0.05 \times 6.02 \times 10^{23}$

$$= 3.01 \times 10^{22}$$

As one molecule of water contains one oxygen atom,

So, number of oxygen atoms in 3.01×10^{22} molecules of water

$$= \mathbf{3.01 \times 10^{22}}$$

Example - 30

What is the mass of 3.01×10^{22} molecules of ammonia ?

Sol. Gram-molecular mass of ammonia = 17 g

Number of molecules in 17 g (one mole) of $NH_3 = 6.02 \times 10^{23}$

Let the mass of 3.01×10^{22} molecules of NH_3 be = x g

So, $$\frac{3.01\times10^{22}}{6.02\times10^{23}} = \frac{x}{17}$$

or $$x = \frac{17\times3.01\times10^{22}}{6.02\times10^{23}} = \mathbf{0.85\ g}$$

Example - 31

How many molecules and atoms of oxygen are present in 5.6 litres of oxygen (O_2) at NTP ?

Sol. We know that 22.4 litres of oxygen at NTP contain 6.02×10^{23} molecules of oxygen.

So, 5.6 litres of oxygen at NTP contain

$$= \frac{5.6}{22.4} \times 6.02 \times 10^{23} \text{ molecules}$$

$= 1.505 \times 10^{23}$ molecules

1 molecule of oxygen contains

= 2 atoms of oxygen

So, 1.505×10^{23} molecules of oxygen contain

$= 2 \times 1.505 \times 10^{23}$ atoms

$= \mathbf{3.01 \times 10^{23}}$ **atoms**

Example - 32

How many electrons are present in 1.6 g of methane ?

Sol. Gram-molecular mass of methane

$(CH_4) = 12 + 4 = 16$ g

Number of moles in 1.6 g of methane $= \frac{1.6}{16} = 0.1$

Number of molecules of methane in 0.1 mole

$= 0.1 \times 6.02 \times 10^{23}$

$= 6.02 \times 10^{22}$

One molecule of methane has = 6 + 4 = 10 electrons

So, 6.02×10^{22} molecules of methane have

$= 10 \times 6.02 \times 10^{22}$ electrons

$= \mathbf{6.02 \times 10^{23}}$ **electrons**

Example - 33

Calculate the number of moles in 25 g of calcium carbonate and number of oxygen atoms.

Sol. Formula mass of calcium carbonate

$(CaCO_3) = 100$

No. of moles of $CaCO_3 = \frac{\text{Mass in grams}}{\text{Formula mass}} = \frac{25}{100}$

= 0.25 mole

No. of oxygen atoms in one mole of $CaCO_3$

$= 3 \times 6.02 \times 10^{23}$

No. of oxygen atoms in 0.25 mole of $CaCO_3$

$= 0.25 \times 3 \times 6.02 \times 10^{23}$

$= \mathbf{4.515 \times 10^{23}}$

Example - 34

One atom of an element weighs 6.644×10^{-23} g. Calculate the number of gram atoms in 40 kg of it.

Sol. Atomic mass of the element

= Mass of one atom $\times 6.02 \times 10^{23}$

$= 6.644 \times 10^{-23} \times 6.02 \times 10^{23}$

= 40 g

40 kg = 40,000 g

Number of grams atoms $= \frac{\text{Mass of the element in grams}}{\text{Atomic mass in grams}}$

$$= \frac{40000}{40} = \mathbf{1000}$$

Example - 35

250 cm^3 of sulphuric acid solution contain 24.5 g of H_2SO_4. If the density of the solution is 1.98 g cm^{-3}, determine (i) molarity and (ii) molality.

Sol. **(i)** Molecular mass of $H_2SO_4 = 2 + 32 + 64 = 98$

No. of moles of H_2SO_4 in solution $= \frac{24.5}{98} = 0.25$

Volume of solution $= 250\ cm^3 = 0.250\ L$

$$\text{Molarity} = \frac{0.25}{0.250} = \mathbf{1\ M}$$

(ii) Mass of solution $= 250 \times 1.98 = 495.0$ g

Mass of solvent = Mass of solution – Mass of solute

$= 495.0 - 24.5 = 470.5 g = 0.4705$ kg

$$\text{Moality} = \frac{0.25}{0.4705} = \mathbf{0.53\ m}$$

Example - 36

Calculate the concentration of nitric acid in moles per litre in a sample which has a density, 1.41 g mL^{-1} and mass per cent of nitric acid in it being 69%.

Sol. Mass percent of 69% means that 100 g of nitric acid solution contain 69 g of nitric acid by mass.

Molar mass of nitric acid (HNO_3) $= 1 + 14 + 48 = 63$ g mol^{-1}

$$\therefore \text{Moles of 68 g } HNO_3 = \frac{69\ g}{63\ g\ mol^{-1}} = 1.095 \text{ mole}$$

$$\text{Volume of 100 g nitric acid solution} = \frac{100\ g}{1.41 g\ mL^{-1}}$$

$= 70.92\ mL = 0.07092\ L$

$$\therefore \text{Conc. of } HNO_3 \text{ in moles per litre} = \frac{1.095 \text{ mole}}{0.07092 L}$$

= 15.44 M

Example - 37

How much copper can be obtained from 100 g of copper sulphate ($CuSO_4$) ? (Atomic mass of cu = 63.5 amu)

Sol. 1 mole of $CuSO_4$ contains 1 mole (1 g atom) of Cu

Molar mass of $CuSO_4 = 63.5 + 32 + 4 \times 16 = 159.5$ g mol^{-1}

Thus, Cu that can be obtained from 159.5 g of $CuSO_4$

$= 63.5$ g

$\therefore$ Cu that can be obtained from 100 g of $CuSO_4$

$$= \frac{63.5}{159.5} \times 100 g$$

= 39.81 g

Example - 38

If the density of methanol is 0.793 kg L^{-1}, what is the volume needed for making 2.5 L of its 0.25 M solution ?

Sol. Molar mass of methanol (CH_3OH) = 32 g mol^{-1}

$= 0.032$ kg mol^{-1}

$$\text{Molarity of the given solution} = \frac{0.793\ kg\ L^{-1}}{0.032\ kg\ mol^{-1}}$$

$= 24.78$ mol L^{-1}

$$\text{Applying} \quad \underset{\text{(Given solution)}}{M_1 \times V_1} = \underset{\text{(Solution to be prepared)}}{M_2 V_2}$$

$24.78 \times V_1 = 0.25 \times 2.5\ L$ or $V_1 = 0.02522\ L = \mathbf{25.22\ mL}$

Example - 39

Pressure is determined as force per unit area of the surface. The S.I. unit of pressure, pascal, is

1 Pa = 1 N m^{-2}

If mass of air at sea level is 1034g cm^{-2}, calculate the pressure in pascal.

Sol. Pressure is the force (i.e., weight) acting per unit area

But weight = mg

$$\therefore \text{Pressure} = \text{Weight per unit area} = \frac{1034 g \times 9.8\ ms^{-2}}{cm^2}$$

$$\frac{1034 g \times 9.8\ ms^{-2}}{cm^2} \times \frac{1 kg}{1000 g} \times \frac{100\ cm}{1 m} \times \frac{100 cm}{1 m} \times \frac{1 N}{kg\ ms^{-2}} \times \frac{1 Pa}{1 N\ m^{-2}}$$

$= \mathbf{1.01332 \times 10^5\ Pa}$

Example - 40

Calculate the empirical formula of a compound that contains 26.6% potassium, 35.4% chromium and 38.1% oxygen [Given K = 39.1; Cr = 52; O = 16]

Sol.

Element	Percentage	Atomic mass
Potassium	26.6	39.1
Chromium	35.4	52.0
Oxygen	38.1	16.0

Relative no. of atoms	Simplest ratio	Simplest whole no. ratio
$\frac{26.6}{39.1} = 0.68$	$\frac{0.68}{0.68} = 1$	$1 \times 2 = 2$
$\frac{35.4}{52} = 0.68$	$\frac{0.68}{0.68} = 1$	$1 \times 2 = 2$
$\frac{38.1}{16} = 2.38$	$\frac{2.38}{0.68} = 3.5$	$3.5 \times 2 = 7$

Therefore, empirical formula is $\mathbf{K_2Cr_2O_7}$.

Example - 41

(a) Calculate the mass of $KClO_3$ necessary to produce 1.23 g O_2.

(b) What mass of KCl is produced along with this quantity of oxygen ?

Sol. (a) The reaction involved is :

$$\underset{\substack{2\text{ mol}\\2\times122.5\text{ g}}}{2KClO_3} \longrightarrow \underset{\substack{2\text{ mol}\\2\times74.5\text{ g}}}{2KCl} + \underset{\substack{3\text{ mol}\\3\times32\text{ g}}}{3O_2}$$

$\because$ 3 × 32 g O_2 is produced by 2 × 122.5 g $KClO_3$

$\therefore$ 1.23 g O_2 will be produced by $\frac{245}{96} \times 1.23 = \mathbf{3.139\ g}$

(b) $\because$ 2 × 122.5 g $KClO_3$ give 2 × 74.5 g KCl

$\therefore$ 3.139 g $KClO_3$ will give $\frac{2\times74.5\times3.139}{2\times122.5} = \mathbf{1.909\ g}$

Example - 42

Calculate the number of atoms in each of the following samples:

(a) 800 amu of Ca (b) 800 grams of Ca

Sol :

(a) Atomic Mass of Ca = 40 amu

$\Rightarrow$ 40 amu is the mass of 1 Ca atom

Thus, 800 amu is the mass of 800/40 Ca atoms

= **20 Ca atoms Ans.**

(b) Atomic mass of Ca = 40 g/mole

$\Rightarrow$ 40g is the mass of 1 mole Ca atoms

= 6.022×10^{23} Ca atoms

Thus, 800g is the mass of $(800 \times 6.022 \times 10^{23})/40$ Ca atoms

= 20 mole Ca atoms

= $\mathbf{1.2044 \times 10^{25}}$ **Ca atoms Ans.**

Example - 43

Calculate the mass of carbon in 1kg of sugar ($C_{12}H_{22}O_{11}$)

Sol : Molecular mass of sugar = 12 × 12 + 22 × 1 + 11 × 16

= 342 g/mol

342g sugar contains = 144g carbon

1000g sugar contains = 421g carbon

Example - 44

Find the amount of weight of NH_3 being produced when 1kg of N_2 reacts with 1kg of H_2. Which reactant is in excess and how much?

Sol : $N_2 + 3H_2 \rightarrow 2NH_3$

1 mole of N_2 reacts with 3 moles of H_2 to produce 2 moles of NH_3. Thus, 28g N_2 reacts with 6g of H_2 to produce 34g of NH_3.

Since the weight of N_2 and H_2 taken are equal, so N_{2-} will be consumed before H_2. So, N_2 is th LR and H_2 is the ER.

Since, 28g N_{2-} reacts with = 6g H_2;

$1000g\ N_2$ reacts = with $1000 \times 6/28 = 214.3g\ H_2$

So, H_2 is the ER and the amount of H_2 in excess

= 1000-214.3 = **785.7g Ans.**

Also, 28g N_2 produces = 34g NH_3;

so, 1000g N_2 produces = $1000 \times 34/28$

= 1.214kg NH_3 Ans.

Example - 45

Calculate the Molarity and molality of a 98% by mass of H_2SO_4 solution having a density of 1.25g/cc.

Sol : H_2SO_4 taken = 98% $\Rightarrow$ 100g of solution contains 98g H_2SO_4.

mass of solution = 100g

mass of solute, H_2SO_4 = 98g

mass of solvent = 100 – 98 = 2g = 0.002 kg

moles of solute, $H_2SO_4 = \frac{98}{98} = 1$

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

$= \frac{100}{1.25} = 80\text{mL} = 0.08\text{L}$

Molarity, $M = \frac{\text{moles of solute}}{\text{volume of solution (L)}} = \frac{1}{0.08}$

= 12.5 M Ans.

molality, $m = \frac{\text{moles of solute}}{\text{mass of solvent (kg)}} = \frac{1}{0.02}$

= 500 m Ans.

Example - 46

A 3M 3L solution of NaOH is mixed with another 3M 5L solution of NaOH. How much should the mixture be diluted so that the final Molarity of the solution become 1M ?

Sol : Moles of NaOH in 1st solution = MV = 3 × 3 = 9.

Moles of NaOH in 2nd solution = 3 × 5 = 15.

Thus on mixing the total moles of NaOH = 24.

Final Molarity = 1M

Final moles = 24

Total Volume of solutions = 8L.

$\Rightarrow V = 24L \left(\text{As } M = \frac{n}{v}\right)$ **Ans.**

The mixture needs to be diluted 3 folds

Example - 47

An organic containing C,H and N gave the following analysis: C: 40% H:13.3%, N:46.67%. If its molecular formula weight is three times its empirical formula weight then find out its empirical and molecular formula of the compound.

Sol: Relative no. of atoms of C = 40/12 = 3.33

Relative no. of atoms of H = 13.3/1 = 13.3 and that for N = 46.67/14 = 3.33

Thus, simplest atomic ratio C:H:N

= 3.33:13.33:3.33 = 1:4:1

Therefore the empirical formula of the compound is **CH_4N Ans.**

Also, given: $\frac{\text{Molecular Formula Mass}}{\text{Empirical Formula Mass}} = 3 =$ **n-factor**

Therefore, molecular formula is $(CH_4N)_3$ i.e. $C_3H_{12}N_3$

Example - 48

Calculate the number of equivalents in the following samples:

(a) 490g H_2SO_4 (b) 1600g NaOH

(c) 730g HCl (d) 0.37g $Ca(OH)_2$

Sol : Eq. wt. of H_2SO_4 = 98/2 = 49; NaOH = 40/1 = 40;

HCl = 36.5/1 = 36.5; $Ca(OH)_2$ = 74/2 = 37

(a) No. of eq. of H_2SO_4 = 490/49 = **10 Ans.**

(b) No. of eq. of NaOH = 1600/40 = **40 Ans.**

(c) No. of eq. of HCl = 730/36.5 = **20 Ans.**

(d) No. of eq. of $Ca(OH)_2$ = 0.37/37 = 0.01

= 10 milli-eq. Ans

Example - 49

A mixture of three acids 3.65 g of HCl, 4.9 g H_2SO_4 and 9 g $H_2C_2O_4$ is made to react with a mixture of two bases x g NaOH and 7.4 g $Ca(OH)_2$. Calculate w for complete neutralisation.

Sol : We know that total equivalents of acids must be equal to total equivalents of bases.'

$\Sigma\,(w/E)_{ACIDS} = \Sigma\,(w/E)_{BASES}$

3.65/36.5 + 4.9/49 + 9/45 = x/40 + 7.4/37

$\Rightarrow$ **x = 8g**

Example - 50

Calculate the Equivalent mass of $Al_2(SO_4)_3$?

Sol : 1 equivalent of $Al_2(SO_4)_3$ = 1 equivalent of Al^{3+} + 1 equivalent of SO_4^{2-}

$E(Al_2(SO_4)_3) = E(Al^{3+}) + E(SO_4^{2-})$

$$\left(\frac{27}{3}\right)+\left(\frac{96}{2}\right)=9+48=57\text{g}$$

This can be tallied by the method for the salt. For this salt z = 6 and M = 342 g therefore E = 342/6 = 57 g.

Example - 51

25 mL of a solution of Na_2CO_3 having a specific gravity of 1.25g mL^{-1} required 32.9 mL of a solution of HCl containing 109.5 g of the acid per litre for complete neutralization. Calculate the volume of 0.84 N H_2SO_4 that will be completely neutralized by 125g of Na_2CO_3 solution.

Sol : equivalents of HCl = $\frac{109.5}{36.5} = 3$

$$N_{HCl} = \frac{3}{1} = 3$$

Since Na_2CO_3 is completely neutralized by HCl

$\therefore$ Meq. of Na_2CO_3 = Meq. of HCl

$N \times 25 = 32.9 \times 3$

$\therefore$ $N_{Na_2CO_3} = 3.948$

Now Na_2CO_3 fresh solution reacts with H_2SO_4

Wt. of Na_2CO_3 solution = 125 g

$\therefore$ Volume of Na_2CO_3 solution $\frac{125}{1.25} = 100$ mL

$\therefore$ Meq. of H_2SO_4 = Meq. of Na_2CO_3

$0.84 \times V = 100 \times 3.948$

$\therefore$ Volume of H_2SO_4 required = 470 mL

Example - 52

5 mL of 8N HNO_3, 4.8 mL of 5N HC*l* and a certain volume of 17M H_2SO_4 are mixed together and made upto 2 litre 30 mL of this acid mixture exactly neutralizes 42.9 mL of Na_2CO_3 solution containing 1g of $Na_2CO_3 \cdot 10H_2O$ in 100 mL of water. Calculate the amount of sulphate ions in g present in solution.

Sol. Meq. of HNO_3 = 5 × 8 = 40

Meq. of HC*l* = 4.8 × 5 = 24

Meq. of H_2SO_4 = V × 17 × 2 = 34 V (Let V mL of H_2SO_4)

$\therefore$ Total Meq. of acid in 2 litre solution = 40 + 24 + 34V

= 64 + 34V

Now Meq. of acid in 30 mL solution = Meq. of Na_2CO_3 used for it

Meq. of Na_2CO_3

$$= 42.9 \times \frac{1 \times 1000}{286/2 \times 100} = 3 \left(N_{Na_2CO_3} = \frac{1}{286/2} \times \frac{1000}{100}\right)$$

$\therefore$ Meq. of acid in 2 litre solution = $\frac{3 \times 2000}{30} = 200$

$\therefore$ 64 + 34V = 200 $\quad\therefore$ 34V = 200 – 64 = 136

Now Meq. of H_2SO_4 = Meq. of SO_4^{-2} = 34V = 136

$\therefore$ Meq. of $SO_4^{-2} = 136$ $\quad\therefore \frac{w}{96/2} \times 1000 = 136$

$\therefore$ Weight of $SO_4^{-2} = 6.528$g

EXERCISE - 1 : BASIC OBJECTIVE QUESTIONS

Atoms

1. Which of the following contains atoms equal to those in 12 g Mg ? (At. wt. Mg = 24)

(a) 12 gm C (b) 7 gm N_2

(c) 32 gm O_2 (d) None of These

2. If $1\frac{1}{2}$ moles of oxygen combine with Al to form Al_2O_3, the weight of Al used in the reaction is (Al = 27)

(a) 27 g (b) 54 g

(c) 40.5 g (d) 81 g

3. Which has the highest mass ?

(a) 50 g of iron (b) 5 moles of N_2

(c) 0.1 mol atom of Ag (d) 10^{23} atoms of carbon

4. The number of atoms present in 0.5 mole of nitrogen is same as the atoms in

(a) 12 g of C (b) 64 g of S

(c) 8 g of O (d) 48 g of Mg

5. Which of the following weighs the least ?

(a) 2 g atom of N (at. wt. of N = 14)

(b) 3×10^{23} atoms of C (at. wt. of C = 12)

(c) 1 mole of S (at. wt. of S = 32)

(d) 7 g silver (at. wt. of Ag = 108)

6. If N_A is Avogadro's number then number of valence electrons in 4.2 g of nitride ions (N^{3-}) is

(a) 2.4 N_A (b) 4.2 N_A

(c) 1.6 N_A (d) 3.2 N_A

7. 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 = 56) present in one molecule of haemoglobin is

(a) 6 (b) 1

(c) 4 (d) 2

Molecules

8. The number of molecules in 4.25 g of ammonia is about

(a) 1.0×10^{23} (b) 1.5×10^{23}

(c) 2.0×10^{23} (d) 2.5×10^{23}

9. If 20% nitrogen is present in a compound, its minimum molecular weight can be

(a) 144 (b) 28

(c) 100 (d) 70

10. The weight of molecule of the compound $C_{60}H_{122}$ is

(a) 1.4×10^{-21} g (b) 1.09×10^{-21} g

(c) 5.025×10^{23} g (d) 16.023×10^{23} g

11. Choose the wrong statement :

(a) 1 mole means 6.02×10^{23} particles

(b) Molar mass is mass of one molecule

(c) Molar mass is mass of one mole of a substance

(d) Molar mass is molecular mass expressed in grams

12. Which among the following is the heaviest ?

(a) One mole of oxygen

(b) One molecule of sulphur trioxide

(c) 100 amu of uranium

(d) 44g of carbon dioxide

13. Rearrange the following I to IV in order of increasing masses and choose the correct answer [At. wt. of N = 14 u, O = 16 u, Cu = 63 u]

I 1 molecule of oxygen

II 1 atom of nitrogen

III 1×10^{-10} mol molecule of oxygen

IV 1×10^{-10} mol atom of copper

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

(c) II > I > III > IV (d) I < II < IV < III

14. The number of moles of SO_2Cl_2 in 13.5 g is :

(a) 0.1 (b) 0.2

(c) 0.3 (d) 0.4

15. The largest number of molecules is in

(a) 36 g of water

(b) 28 g of carbon monoxide

(c) 46 g of ethyl alcohol

(d) 54 g of nitrogen pentoxide.

16. Which of the following contains maximum number of atoms ?

(a) 6.023×10^{21} molecules of CO_2

(b) 22.4 L of CO_2 at STP

(c) 0.44 g of CO_2

(d) None of these

Stoichiometric Calculations

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

(a) 0.7 (b) 0.5

(c) 0.30 (d) 0.10

18. One mole of a mixture of CO and CO_2 requires exactly 20 gram of NaOH in solution for complete conversion of all the CO_2 into Na_2CO_3. How many moles more of NaOH would it require for conversion into Na_2CO_3 if the mixture (one mole) is completely oxidised to CO_2.

(a) 0.2 (b) 0.5

(c) 0.4 (d) 1.5

19. The number of water molecules present in a drop of water (volume = 0.0018 ml) at room temperature is (density of H_2O = 1 g/mL)

(a) 6.023×10^{19} (b) 1.084×10^{18}

(c) 4.84×10^{17} (d) 6.023×10^{23}

20. What is the weight of oxygen required for the complete combustion of 2.8 kg of ethylene ?

(a) 2.8 kg (b) 6.4 kg

(c) 9.6 kg (d) 96 kg

21. A sample of pure calcium weighing 1.35 g was quantitatively converted to 1.88 g of pure calcium oxide. Atomic mass of calcium would be :

(a) 20 (b) 40

(c) 16 (d) 35.5

22. 30g of magnesium and 30g of oxygen are reacted, then the residual mixture contains

(a) 60g of Magnesium oxide only

(b) 40g of Magnesium oxide and 20 g of oxygen

(c) 45 g of Magnesium oxide and 15g of oxygen

(d) 50 g of Magnesium oxide and 10g of oxygen

23. Silicon carbide, is produced by heating SiO_2 and C to high temperatures according to the equation :

$$SiO_2\,(s) + 3C\,(s) \rightarrow SiC\,(s) + 2CO\,(g)$$

How many grams of SiC could be formed by reacting 2.00 g of SiO_2 and 2.0 g of C ?

(a) 1.33 (b) 2.56

(c) 3.59 (d) 4.0

24. Given the reaction

$$Pb(NO_3)_2\,(aq) + 2KI \rightarrow PbI_2\,(s) + 2KNO_3\,(aq)$$

What is the mass of PbI_2 that will precipitate if 10.2 g of $Pb(NO_3)_2$ is mixed with 5.73 g of KI in a sufficient quantity of H_2O ?

(a) 2.06 g (b) 4.13 g

(c) 7.96 g (d) 15.9 g

25. If 9 moles of O_2 and 14 moles of N_2 are placed in a container and allowed to react according to the equation :

$$3O_2 + 2N_2 \rightarrow 2N_2O_3$$

The reaction proceeds until 3 moles of O_2 remain, how many moles of N_2O_3 are present at that instant ?

(a) 6 (b) 3

(c) 4 (d) 12

26. Iron (III) oxide can be reduced with CO to foum metalic iron as described by unbalanced chemical reaction

$Fe_2O_3 + CO \rightarrow Fe + CO_2$

The number of moles of CO required to form one mole of Fe from its oxide is

(a) 1 (b) 1.5

(c) 2 (d) 3

Percentage Purity

27. The mass of CaO that shall be obtained by heating 20 kg of 90% pure lime-stone ($CaCO_3$) is

(a) 11.2 kg (b) 8.4 kg

(c) 10.08 kg (d) 16.8 kg

28. If potassium chlorate is 80% pure, then 48 g of oxygen would be produced from (atomic mass of K = 39)

(a) 153.12g of $KClO_3$ (b) 122.5 g of $KClO_3$

(c) 245 g of $KClO_3$ (d) 98.0 g of $KClO_3$

Percentage Yield

29. Antimony reacts with sulphur according to the equation

$2Sb(s) + 3S(s) \rightarrow Sb_2S_3(s)$

The molar mass of Sb_2S_3 is 340 g mol^{-1}.

What is the percentrage yield for a reaction in which 1.40 g of Sb_2S_3 is obtained from 1.73 g of antimony and a slight excess of sulphur ?

(a) 80.9 % (b) 58.0 %

(c) 40.5 % (d) 29.0 %

30. NH_3 is produced according to the following reaction :

$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$

In an experiment 0.25 mol of NH_3 is formed when 0.5 mol of N_2 is reacted with 0.5 mol of H_2. What is % yield ?

(a) 75% (b) 50%

(c) 33% (d) 25%

Strength : Mass Percent

31. What is the weight % sulhuric acid in an aqueous solution which is 0.502 M in sulphuric acid ? The specify gravity of the solution is 1.07

(a) 4.77 % (b) 5.67 %

(c) 9.53 % (d) 22.0 %

32. Mole fraction of ethanol in ethanol - water mixture is 0.25. Hence, percentage concentration of ethanol (C_2H_6O) by weight of mixture is

(a) 25 (b) 75

(c) 46 (d) 54

Strength : Molality

33. A molal solution is one that contains one mole of a solute in

(a) 1000 g of the solvent

(b) one litre of the solvent

(c) one litre of the solution

(d) 22.4 litres of the solution

34. An aqueous solution of ethanol has density 1.025 g/mL and it is 2 M. What is the molality of this solution ?

(a) 1.79 (b) 2.143

(c) 1.951 (d) None of these

35. What volume of 0.4 M $FeCl_3 . 6H_2O$ will contain 600 mg of Fe^{3+} ?

(a) 49.85 mL (b) 26.78 mL

(c) 147.55 mL (d) 87.65 mL

36. A sample of H_2SO_4 (density 1.8 g/ml) is 90% by weight. What is the volume of the acid that has to be used to make 1 litre of 0.2 M H_2SO_4?

(a) 16 mL (b) 10 mL

(c) 12 mL (d) 18 mL

37. The density (in g mL^{-1}) of a 3.60 M sulphuric acid solution that is 29% H_2SO_4 (molar mass = 98 g mol^{-1}) by mass will be

(a) 1.45 (b) 1.64

(c) 1.88 (d) 1.22

38. An antifreeze mixture contains 40% ethylene glycol ($C_2H_6O_2$) by weight in the aqueous solution. If the density of this solution is 1.05 g mL, what is the molar concentration?

(a) 6.77 M (b) 6.45 M

(c) 0.0017 M (d) 16.9 M

39. What is the molarity of SO_4^{2-} ion in aqueous solution that contain 34.2 ppm of $Al_2(SO_4)_3$? (Assume complete dissociation and density of solution 1 g/mL)

(a) 3×10^{-4} M (b) 2×10^{-4} M

(c) 10^{-4} M (d) None of these

Strength : Mole Fraction

40. The mole fraction of a given sample of I_2 in C_6H_6 is 0.2. The molality of I_2 in C_6H_6 is

(a) 0.32 (b) 3.2

(c) 0.032 (d) 0.48

Strength : Variation

41. In which mode of expression, the concentration of a solution remains independent of temperature ?

(a) Molarity (b) Normality

(c) Formality (d) Molality

42. With increase of temperature, which of these changes ?

(a) molality

(b) weight fraction of solute

(c) fraction of solute present in unit volume of water

(d) mole fraction.

43. Molarity and Normality changes with temperature because they involve :

(a) Moles (b) equivalents

(c) weights (d) volumes

44. When 500.0 mL of 1.0 M $LaCl_3$ and 3.0 M NaCl are mixed. What is molarity of Cl^- ion ?

(a) 4.0 M (b) 3.0 M

(c) 2.0 M (d) 1.5 M

45. When 50 mL of 2.00 M HCl, 100 mL of 1.00 M HCl and 100 mL of 0.500 M HCl are mixed together, the resulting HCl concentration of the solution is

(a) 0.25 M (b) 1.00 M

(c) 3.50 M (d) 6.25 M

46. A sample of H_2SO_4 (density 1.8 g mL^{-1}) is 90% by weight. What is the volume of the acid that has to be used to make 1 L of 0.2 M H_2SO_4 ?

(a) 16 mL (b) 18 mL

(c) 12 mL (d) 10 mL

Strength : Stoichiometric Calculations

47. What is the concentration of nitrate ions if equal volumes of 0.1 M $AgNO_3$ and 0.1 M NaCl are mixed together ?

(a) 0.1 M (b) 0.2 M

(c) 0.05 M (d) 0.25 M

48. How many grams of NaBr could be formed if 14.2 g of NaI are reacted with 40.0 mL of a 0.800 M Br_2 ?

$2NaI + Br_2 \rightarrow 2NaBr + I_2$

(a) 3.30 (b) 4.80

(c) 6.59 (d) 9.75

49. If AgBr is assumed to be completely insoluble, What mass of AgBr precipitates when 30.0 mL of a 0.500 mol/L solution of $AgNO_3$ is added to 50.0 mL of an 0.400 mol/L solution of NaBr ?

(a) 3.76 g (b) 1.28 g

(c) 2.82 g (d) 3.76 kg

50. In a titration, 15.0 cm_3 of 0.100 M HCl neutralizes 30.0 cm_3 of $Ca(OH)_2$. What is the molarity of $Ca(OH)_2$ solution ?

(a) 0.0125 (b) 0.0250

(c) 0.0500 (d) 0.200

51. 10 mL of 1 M $BaCl_2$ solution and 5 mL 0.5 M K_2SO_4 are mixed together to precipitate out $BaSO_4$. The amount of $BaSO_4$ precipated will be

(a) 0.005 mol (b) 0.00025 mol

(c) 0.025 mol (d) 0.0025 mol

Molar Volume of Gas based Calculations

52. M g of a substance when vaporised occupy a volume of 5.6 litre at NTP. The molecular mass of the substance will be :

(a) M (b) 2M

(c) 3M (d) 4M

53. Number of molecules in 1 litre of oxygen at NTP is :

(a) $\frac{6.02\times10^{23}}{32}$ (b) $\frac{6.02\times10^{23}}{22.4}$

(c) 32×22.4 (d) $\frac{32}{22.4}$

54. The number of molecules in 89.6 litre of a gas at NTP are :

(a) 6.02×10^{23} (b) $2\times6.02\times10^{23}$

(c) $3\times6.02\times10^{23}$ (d) $4\times6.02\times10^{23}$

55. The mass of 112 cm^3 of CH_4 gas at STP is

(a) 0.16 g (b) 0.8 g

(c) 0.08 g (d) 1.6 g

Empirical Formula

56. An oxide of metal (M) has 40% by mass of oxygen. Metal M has atomic mass of 24. The empirical formula of the oxide is

(a) M_2O (b) M_2O_3

(c) MO (d) M_3O_4

57. What is the empirical formula of a compound composed of O and Mn in equal weight ratio ?

(a) MnO (b) MnO_2

(c) Mn_2O_3 (d) Mn_2O_7

58. Determine the empirical formula of Kelvar, used in making bullet proof vests, is 70.6% C, 4.2% H, 11.8% N and 13.4% O :

(a) $C_7H_5NO_2$ (b) $C_7H_5N_2O$

(c) C_7H_9NO (d) C_7H_5NO

59. A compound contains atoms of three elements A, B and C. If the oxidation number of A is +2, B is +5 and C is –2, the possible formula of the compound is :

(a) $A(BC_3)_2$ (b) $A_3(BC_4)_2$

(c) $A_3(B_4C)_2$ (d) ABC_2

60. The carbonate of a metal is isomorphous (similar formula) with magnesium carbonate and contains 6.091 percent of carbon. The atomic weight of metal is

(a) 24 (b) 56

(c) 137 (d) 260

61. The Ew of an element is 13. It forms an acidic oxide which with KOH forms a salt isomorphous with K_2SO_4. The atomic weight of element is

(a) 13 (b) 26

(c) 52 (d) 78

62. A hydrate of Na_2SO_3 losses 22.2% of H_2O by mass on strong heating. The hydrate is

(a) $Na_2SO_3\cdot4H_2O$ (b) $Na_2SO_3\cdot6H_2O$

(c) $Na_2SO_3\cdot H_2O$ (d) $Na_2SO_3\cdot2H_2O$

Laws of Chemical Combination

63. One of the following combinations illustrate law of reciprocal proportions

(a) N_2O_3, N_2O_4, N_2O_5 (b) NaCl, NaBr, NaI

(c) CS_2, CO_2, SO_2 (d) PH_3, P_2O_3, P_2O_5

64. If water samples are taken from sea, river, clouds, lake or snow, they will be found to contain H_2 and O_2 in the approximate ratio of 1 : 8. This indicates the law of

(a) Multiple proportion (b) Definite proportion

(c) Reciprocal proportions (d) none of these

65. The law of multiple proportion is illustrated by

(a) Carbon monoxide and carbon dioxide

(b) Potassium bromide and potassium chloride

(c) Water and heavy water

(d) Calcium hydroxide and barium hydroxide

66. The percentage of copper and oxygen in samples of CuO obtained by different methods were found to be the same. This illustrates the law of

(a) constant proportions (b) conservation of mass

(c) multiple proportions (d) reciprocal proportions

67. Two samples of lead oxide were separately reduced to metallic lead by heating in a current of hydrogen. The weight of lead from one oxide was half the weight of lead obtained from the other oxide. The data illustrates.

(a) law of reciprocal proportions

(b) law of constant proportions

(c) law of multiple proportions

(d) law of equivalent proportions

68. One part of an element A combines with two parts of another element B. Six parts of the element C combine with four parts of the element B. If A and C combine together the ratio of their weights will be governed by

(a) law of definite proportions

(b) law of multiple proportions

(c) law of reciprocal proportions

(d) law of conservation of mass.

69. n g of substance X reacts with m g of substance Y to form p g of substance R and q g of substance S. This reaction can be represented as follows :

$$X + Y = R + S$$

The relation which can be established in the amounts of the reactants and the products will be

(a) $n - m = p - q$ (b) $n + m = p + q$

(c) $n = m$ (d) $p = q$

70. Which one is the best example of law of conservation of mass ?

(a) 6 g of carbon is heated in vacuum, there is no change in mass

(b) 6 g of carbon combines with 16 g of oxygen to form 22 g of CO_2

(c) 6 g water is completely converted into steam

(d) A sample of air is heated at constant pressure when its volume increases but there in no change in mass.

71. SO_2 gas was prepared by (i) burning sulphur in oxygen, (ii) reacting sodium sulphite with dilute H_2SO_4 and (iii) heating copper with conc. H_2SO_4. It was found that in each case sulphur and oxygen combined in the ratio of 1 : 1. The data illustrates the law of :

(a) conservation of mass (b) multiple proportions

(c) constant proportions (d) reciprocal proportions

72. A sample of $CaCO_3$ has Ca = 40%, C = 12% and O = 48%. If the law of constant proportions is true, then the mass of Ca in 5 g of $CaCO_3$ from another source will be :

(a) 2.0g (b) 0.2g

(c) 0.02g (d) 20.0g

73. H_2S contains 5.88% hydrogen, H_2O contains 11.11% hydrogen while SO_2 contains 50% sulphur. These figures illustrate the law of :

(a) conservation of mass (b) constant proportions

(c) multiple proportions (d) reciprocal proportions

74. Hydrogen combines with chlorine to form HCl. It also combines with sodium to form NaH. If sodium and chlorine also combine with each other, they will do so in the ratio of their masses as :

(a) 23 : 35.5 (b) 35.5 : 23

(c) 1 : 1 (d) 23 : 1

Principle of Atom Conservation

75. x g of Ag was dissolved in HNO_3 and the solution was treated with excess of NaCl when 2.87 g of AgCl was precipitated. The value of x is

(a) 1.08 g (b) 2.16 g

(c) 2.70 g (d) 1.62 g

76. A 1.50 g sample of an ore containing silver was dossolved, and all the Ag^+ was converted to 0.125 g Ag_2S. What was the percentage of silver in the ore ?

(a) 14.23% (b) 10.8%

(c) 8.27% (d) 7.2%

77. NaOH is formed according to the reaction

$$2Na + \frac{1}{2}O_2 \rightarrow Na_2O$$

$$Na_2O + H_2O \rightarrow 2NaOH$$

To make 4g of NaOH, Na required is

(a) 4.6g (b) 4.0g

(c) 2.3g (d) 0.23g

Equivalent Concept

78. $2H_3PO_4 + 3\,Ca(OH)_2 \rightarrow Ca_3(PO_4)_2 + 6\,H_2O$

Equivalent weight of H_3PO_4 in this reaction is

(a) 98 (b) 49

(c) 32.66 (d) 24.5

79. The Ew of H_3PO_4 in the reaction is

$Ca(OH)_2 + H_3PO_4 \rightarrow CaHPO_4 + 2H_2O$

$(Ca = 40, P = 31, O = 16)$

(a) 49 (b) 98
(c) 32.66 (d) 147

80. What weight of a metal of equivalent weight 12 will give 0.475 g of its chloride ?

(a) 0.12 g (b) 0.24 g
(c) 0.36 g (d) 0.48 g

81. How many grams of phosphoric acid would be needed to neutralise 100 g of magnesium hydroxide ? (The molecular weights are : $H_3PO_4 = 98$ and $Mg\,(OH)_2 = 58.3$)

(a) 66.7 g (b) 252 g
(c) 112 g (d) 168 g

82. 0.116 g of $C_4H_4O_4$ (A) is neutralised by 0.074 g of $Ca(OH)_2$. Hence, protonic hydrogen $(H^{\oplus})$ in (A) will be

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

83. 4.2 g of metallic carbonate MCO_3 was heated in a hard glass tube and CO_2 evolved was found to have 1120 mL of volume at STP. The EW of the metal is

(a) 12 (b) 24
(c) 18 (d) 15

84. 1.0 g of a monobasic acid when completely aceted upon Mg gave 1.301 g of anhydrous Mg salt. Equivalent weight of acid is

(a) 35.54 (b) 36.54
(c) 17.77 (d) 18.27

85. 0.1 g of metal combines with 46.6 mL of oxygen at STP. The equivalent weight of metal is

(a) 12 (b) 24
(c) 6 (d) 36

Normality

86. When 100 ml of 1 M NaOH solution and 10 ml of 10 N H_2SO_4 solution are mixed together, the resulting solution will be :

(a) alkaline (b) acidic
(c) strongly acidic (d) neutral

87. Normality of 0.74 g $Ca(OH)_2$ in 5 mL solution is

(a) 8 N (b) 4 N
(c) 0.4 N (d) 2 N

88. Normality of a 2 M sulphuric acid is

(a) 2 N (b) 4 N
(c) N / 2 (d) N / 4

89. 1 L of a normal solution is diluted to 2000 ml. The resulting normality is :

(a) N / 2 (b) N/ 4
(c) N (d) 2 N

90. What volume of 0.232 N solution contains 3.17 milliequivalent of solute ?

(a) 137 mL (b) 13.7 mL
(c) 27.3 mL (d) 12.7 mL

91. 1L solution of NaOH contains 4.0 g of it. What shall be the difference between molarity and the normality ?

(a) 0.10 (b) zero
(c) 0.05 (d) 0.20

92. 100 ml of 0.3 N HCl is mixed with 200 ml of 0.6 N H_2SO_4. The final normality of the resulting solution will be

(a) 0.1 N (b) 0.2 N
(c) 0.3 N (d) 0.5 N

93. Normality of a mixture of 30 mL of 1N H_2SO_4 and 20 mL of 4N H_2SO_4 is

(a) 1.0 N (b) 1.1 N
(c) 2.0 N (d) 2.2 N

94. Normality of solution obtained by mixing 10 mL of 1N HCl, 20 mL of 2N H_2SO_4 and 30 mL of 3N HNO_3 is

(a) 1.11 N (b) 2.22 N
(c) 2.33 N (d) 3.33 N

(Use the Final volume as sum of all volumes).

EXERCISE - 2 : PREVIOUS YEAR JEE MAINS QUESTION

1. Number of atoms in 558.5 Fe (at. wt. 55.85) is **(2002)**

(a) Twice that in 60 g carbon

(b) 6.023×10^{22}

(c) Half in 8 g He (d) $558.5 \times 6.023 \times 10^{23}$

2. In an organic compound of molar mass 108 g mol^{-1}C, H and N atoms are present in 9 : 1 : 3.5 by weight. Molecular formula can be **(2002)**

(a) $C_6H_8N_2$ (b) $C_7H_{10}N$

(c) $C_5H_6N_3$ (d) $C_4H_{18}N_3$

3. Number of atoms in 560g of Fe (atomic mass 56 g mol^{-1}) is **(2002)**

(a) twice that of 70 g N (b) half that of 20 g H

(c) Both (a) and (b) (d) None of the above

4. To neutralize completely 20 mL of 0.1 M aqueous solution of phosphorus (H_3PO_3) acid, the volume of 0.1 M aqueous KOH solution required is **(2004)**

(a) 60 mL (b) 20 mL

(c) 40 mL (d) 10 mL

5. 6.023×10^{20} molecules of urea are present in 100 mL of its solution. The concentration of urea solution is **(2004)**

(a) 0.001 M (b) 0.1 M

(c) 0.02 M (d) 0.01 M

6. What volume of H_2 gas at 273 K and 1 atm pressure will be consumed in obtaining 21.6 g of boron (At. mass 10.8 u) from reduction of boron trichloride by H_2 **(2003)**

(a) 89.6 L (b) 67.2 L

(c) 44.8 L (d) 22.4 L

7. 25 mL of a solution of $Ba(OH)_2$ on titration with a 0.1 M solution of HCl gave a titre value of 35 mL. The molarity of barium hydroxide solution was **(2003)**

(a) 0.07 (b) 0.14

(c) 0.28 (d) 0.35

8. 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 **(2005)**

(a) be a function of the molecular mass of the substance

(b) remain unchanged

(c) increase two fold (d) decrease twice

9. Density of a 2.05 M solution of acetic acid in water is 1.02 g/mL. The molality of the solution is **(2006)**

(a) 0.44 mol Kg^{-1} (b) 1.14 mol kg^{-1}

(c) 3.28 mol kg^{-1} (d) 2.28 mol kg^{-1}

10. How many moles of magnesium phosphate, $Mg_3(PO_4)_2$ will contain 0.25 mole of oxygen atoms ? **(2006)**

(a) 0.02 (b) 3.125×10^{-2}

(c) 1.25×10^{-2} (d) 2.5×10^{-2}

11. The density (in g mL^{-1}) of a 3.60 M sulphuric acid solution that is 29% H_2SO_4 (Molar mass = 98g mol^{-1}) by mass will be **(2007)**

(a) 1.64 (b) 1.88

(c) 1.22 (d) 1.45

12. Amount of oxalic acid present in a solution can be determined by its titration with $KMnO_4$ solution in the presence of H_2SO_4. The titration gives unsatisfactory result when carried out in the presence of HCl because HCl **(2008)**

(a) gets oxidised by oxalic acid to chlorine

(b) furnishes H^+ ions in addition to those from oxalic acid

(c) reduces permanganate to Mn^{2+}

(d) oxidises oxalic acid to carbon dioxide and water

13. The mass of potassium dichromate crystals required to oxidise 750 cm^3 of 0.6 M Mohr's salt solution is (Given molar mass = 392) **(2011)**

(a) 0.49 g (b) 0.45 g

(c) 29.4 g (d) 2.2 g

14. The density of a solution prepared by dissolving 120g of urea (mol. mass = 60 u) in 1000 g of water is 1.15g/mL. The molarity of this solution is **(2012)**

(a) 0.50 M (b) 1.78 M

(c) 1.02 M (d) 2.05 M

15. The molarity of a solution obtained by mixing 750 mL of 0.5 (M) HCl with 250 mL of 2 (M) HCl will be **(2013)**

(a) 0.875 M (b) 1.00 M

(c) 1.75 M (d) 0.0975 M

16. For the estimation of nitrogen, 1.4g of an organic compound was digested by Kjeldahl method and the evolved ammonia was absorbed in 60 mL of $\frac{M}{10}$ sulphuric acid. The unreacted acid required 20 mL of $\frac{M}{10}$ sodium hydroxide for complete neutralization. The percentage of nitrogen in the compound is : **(2014)**

(a) 10% (b) 3%

(c) 5% (d) 6%

17. The ratio of masses of oxygen and nitrogen in a particular gaseous mixture is 1 : 4. The ratio of number of their molecule is : **(2014)**

(a) 7 : 32 (b) 1 : 8

(c) 3 : 16 (d) 1 : 4

18. In Carius method of estimation of halogens, 250 mg of an organic compound gave 141 mg of AgBr. The percentage of bromine in the compound is :

(at. mass Ag = 108; Br = 80) **(2015)**

(a) 48 (b) 60

(c) 24 (d) 36

19. The percent loss in weight after heating a pure sample of potassium chlorate (mol. wt. = 122.5) will be **(2015)**

(a) 12.25 (b) 24.50

(c) 39.18 (d) 49.0

20. 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 ^1H atoms are replaced by ^2H atoms is : **(2017)**

(a) 37.5 kg (b) 7.5 kg

(c) 10 kg (d) 15 kg

21. 1 gram 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 : **(2017)**

(a) 84.3 (b) 118.6

(c) 11.86 (d) 1186

22. The ratio of mass percent 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: **(2018)**

(a) $C_2H_4O_3$ (b) $C_3H_6O_3$

(c) C_2H_4O (d) $C_3H_4O_2$

JEE MAINS ONLINE QUESTION

1. Dissolving 120 g of a compound of (mol. wt. 60) in 1000 g of water gave a solution of density 1.12 g mL^{-1}. The molarity of the solution is:

Online 2014 SET (1)

(a) 1.00 M (b) 2.00 M

(c) 2.50 M (d) 4.00 M

2. The amount of oxygen in 3.6 mol of water is:

Online 2014 SET (1)

(a) 115.2 g (b) 57.6 g

(c) 28.8 g (d) 18.4 g

3. A gaseous compound of nitrogen and hydrogen contains 12.5% (by mass) of hydrogen. The density of the compound relative to hydrogen is16. The molecular formula of the compound is:

Online 2014 SET (2)

(a) N_2H_4 (b) NH_3
(c) N_3H (d) NH_2

4. The amount of $BaSO_4$ formed upon mixing 100 mL of 20.8% $BaCl_2$ solution with 50 mL of 9.8% H_2SO_4 solution will be: (Ba = 137, Cl = 35.5, S = 32, H = 1 and Q = 16) **Online 2014 SET (3)**

(a) 33.2 g (b) 11.65 g
(c) 30.6 g (d) 23.3 g

5. $A + 3B + 3C \rightleftharpoons AB_2C_3$

Reaction of 6.0 g of A, 6.0×10^{23} atoms of B, & 0.036 mol of C yields 4.8 g of compound AB_2C_3. If the atomic mass of A and C are 60 and 80 amu, respectively, the atomic mass of B is (Avogadro no. = 6×10^{23}) : **Online 2015 SET (1)**

(a) 50 amu (b) 60 amu
(c) 70 amu (d) 40 amu

6. 44 g of a sample on complete combustion gives 88 gm CO_2 and 36 gm of H_2O. The molecular formula of the compound may be **Online 2016 SET (1)**

(a) C_4H_6 (b) C_2H_6O
(c) C_2H_4O (d) C_3H_6O

7. The volume of 0.1 N dibasic acid sufficient to neutralize 1g of a base that furnishes 0.04 mole of OH^- in aqueous solution is :**Online 2016 SET (2)**

(a) 200 mL (b) 400 mL
(c) 600 mL (d) 800 mL

8. Excess of NaOH (aq) was added to 100 mL of $FeCl_3$ (aq) resulting into 2.14 g of $Fe(OH)_3$. The molarity of $FeCl_3$ (aq) is :

(Given molar mass of Fe = 56 g mol"1 and molar mass of Cl = 35.5 g mol"1) **Online 2017 SET (1)**

(a) 0.2 M (b) 0.3 M
(c) 0.6 M (d) 1.8 M

9. What quantity (in mL) of a 45% acid solution of a mono-protic strong acid must be mixed with a 20% solution of the same acid to produce 800 mL of a 29.875% acid solution ? **Online 2017 SET (2)**

(a) 320 (b) 325
(c) 316 (d) 330

10. A sample of $NaClO_3$ is converted by heat to NaCl with a loss of 0.16 g of oxygen. The residue is dissolved in water and precipitated as AgCl. The mass of AgCl (in g) obtained will be : (Given : Molar mass of AgCl = 143.5 g mol^{-1})

Online 2018 SET (1)

(a) 0.35 (b) 0.41
(c) 0.48 (d) 0.54

11. For per gram of reactant, the maximum quantity of N_2 gas is produced in which of the following thermal decomposition reactions ? **(Online 2018 SET 2)**

(Given : Atomic wt. - Cr = 52 u, Ba = 137 u)

(a) $(NH_4)_2Cr_2O_7(s) \rightarrow N_2(g) + 4H_2O(g) + Cr_2O_3(s)$

(b) $2NH_4NO_3(s) \rightarrow 2N_2(g) + 4H_2O(g) + O_2(g)$

(c) $Ba(N_3)_2(s) \rightarrow Ba(s) + 3N_2(g)$

(d) $2NH_3(g) \rightarrow N_2(g) + 3H_2(g)$

12. An unknown chlorohydrocarbon has 3.55 percent of chlorine. If each molecule of the hydrocarbon has one chlorine atom only; chlorine atoms present in 1 g of chlorohydrocarbon are :

(Atomic wt. of Cl =35.5 u;

Avogadro constant $= 6.023 \times 10^{23}$ mol^{-1})

(Online 2018 SET 3)

(a) 6.023×10^{20} (b) 6.023×10^{9}
(c) 6.023×10^{21} (d) 6.023×10^{23}

EXERCISE - 3 : ADVANCED OBJECTIVE QUESTIONS

1. All questions marked **"S"** are single choice questions
2. All questions marked **"M"** are multiple choice questions
3. All questions marked **"C"** are comprehension based questions
4. All questions marked **"A"** are assertion–reason type questions

   (A) If both assertion and reason are correct and reason is the correct explanation of assertion.

   (B) If both assertion and reason are true but reason is not the correct explanation of assertion.

   (C) If assertion is true but reason is false.

   (D) If reason is true but assertion is false.
5. All questions marked **"X"** are matrix–match type questions
6. All questions marked **"I"** are integer type questions

Atoms

1. (S) 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) decrease twice

(b) increase two fold

(c) remain unchanged

(d) be a function of the molecular mass of the substance

2. (A) **Assertion :** Both 138 g of K_2CO_3 and 12 g of carbon have same number of carbon atoms.

Reason : Both contains 1 g atom of carbon which contains 6.022×10^{23} carbon atoms.

(a) A (b) B

(c) C (d) D

3. (A) **Assertion :** 1 Avogram is equal to 1 amu.

Reason : Avogram is reciprocal of Avogadro's number.

(a) A (b) B

(c) C (d) D

4. (X)

Column I	Column II
(A) 5.4 g of A*l*	(P) 0.5 N_A electrons
(B) 1.2 g of Mg^{2+}	(Q) 15.9994 amu
(C) Exact atomic weight of	(R) 0.2 mole atoms mixture of oxygen isotopes
(D) 0.9 m*l* of H_2O	(S) 0.05 moles

Molecules

5. (S) If 10^{21} molecules are removed from 200mg of CO_2, then the number of moles of CO_2 left are

(a) 2.85×10^{-3} (b) 28.8×10^{-3}

(c) 0.288×10^{-3} (d) 1.68×10^{-2}

6. (S) A gaseous mixture contains oxygen and nitrogen in the ratio of 1 : 4 by weight. Therefore, the ratio of their number of molecules is

(a) 1 : 4 (b) 1 : 8

(c) 7 : 32 (d) 3 : 16

7. (S) A compound possesses 8% sulphur by mass. The least molecular mass is

(a) 200 (b) 400

(c) 155 (d) 355

8. (M) 8 g O_2 has same number of molecules as that in :

(a) 14 g CO (b) 7 g CO

(c) 11 g CO_2 (d) 22 g CO_2

9. (M) Which of the following have same number of atoms ?

(a) 6.4 g of O_2 (b) 0.1 mol of NH_3

(c) 4.0 g of He (d) 22.4 L of Cl_2 at STP

10. (A) **Assertion :** Number of molecules present in SO_2 is twice the number of molecules present in O_2.

Reason : Molecular mass of SO_2 is double to that of O_2.

(a) A (b) B

(c) C (d) D

Stoichiometric Calculations

11. (S) P and Q are two elements which forms P_2Q_3 and PQ_2. If 0.15 mole of P_2Q_3 weights 15.9g and 0.15 mole of PQ_2 weights 9.3g, the atomic weight of P and Q is (respectively) :

(a) 18, 26 (b) 26,18

(c) 13, 9 (d) None of these

12. (S) 1 mole of oxalic acid is treated with conc. H_2SO_4. The resultant gaseous mixture is passed through a solution of KOH. The mass of KOH consumed will be (where KOH absorbs CO_2.)

$$(COOH)_2 \xrightarrow{H_2SO_4} CO + CO_2 + H_2O$$

$$2\,KOH + CO_2 \longrightarrow K_2CO_3 + H_2O$$

(a) 28 g (b) 56 g

(c) 84 g (d) 112 g

13. (M) 0.2 mole of K_3PO_4 and 0.3 mole of $BaCl_2$ are mixed in 1 L of solution. Which of these is/are correct ?

(a) 0.2 mole of $Ba_3(PO_4)_2$ will be formed

(b) 0.1 mole of $Ba_3(PO_4)_2$ will be formed

(c) 0.6 mole of KCl will be formed

(d) 0.3 mole of KCl will be formed

Comprehension

Often more than one reaction is required to change starting materials into the desired product. This is true for many reaction that we carry out in the laboratory and for many industrial process. These are called sequential reactions. The amount of desired product from each reaction is taken as the starting material for the next reaction.

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

$$II : 4Al + 3O_2 \longrightarrow 2Al_2O_3$$

$KClO_3$ decomposes in step I to give O_2, which in turn, is used by Al to form Al_2O_3 in step II. First we determine O_2 formed in step I and then Al used by this O_2 in step II. Both reactions can be added to determine amount of $KClO_3$ that can give required amount of O_2 needed for Al.

$$Net : 2KClO_3 + 4Al \longrightarrow 2KCl + 2Al_2O_3$$

Thus, $2KClO_3 \equiv 4Al$

Or $KClO_3 \equiv 2Al$.

$$I : CaO + 3C \longrightarrow CaC_2 + CO$$

$$II : CaC_2 + 2H_2O \longrightarrow Ca(OH)_2 + C_2H_2$$

CaC_2 (calcium carbide) is prepared in step I. It is used to prepare acetylene (C_2H_2) in step II. Suppose we want to determine amount of CaO that can give enough CaC_2 to converted required amount of C_2H_2. Amount of CaO is determined in step I and then amount of C_2H_2 in step II. We can relate CaO and C_2H_2 stoichiometrically by writing net reaction which is

$$CaO + 3C + 2H_2O \longrightarrow Ca(OH)_2 + C_2H_2 + CO$$

Thus, $CaO \equiv C_2H_2$

14. (C) NX is produced by the following step of reactions

$$M + X_2 \longrightarrow MX_2$$

$$MX_2 + X_2 \longrightarrow M_3X_8$$

$$M_3X_8 + N_2CO_3 \longrightarrow NX + CO_2 + M_3O_4$$

How much M (metal) is consumed to produce 206 gm of NX. (Take At. wt of M = 56, N=23, X = 80)

(a) 42 gm (b) 56 gm

(c) $\frac{14}{3}$ gm (d) $\frac{7}{4}$ gm

15. (C) The following process has been used to obtain iodine from oil-field brines in California.

$$NaI + AgNO_3 \longrightarrow AgI + NaNO_3$$

$$AgI + Fe \longrightarrow FeI_2 + Ag$$

$$FeI_2 + Cl_2 \longrightarrow FeCl_3 + I_2$$

If 381 kg of iodine is produced per hour then mass of $AgNO_3$ required per hour will be

[atomic mass Ag– 108, I– 127, Fe–56, N–14, Cl–35.5]

(a) 170 kg (b) 340 kg

(c) 255 kg (d) 510 kg

16. (C) 120 gm Mg was burnt in air to give a mixture of MgO and Mg_3N_2. The mixture is now dissolved in HC*l* to form $MgCl_2$ and NH_4Cl, if 107 grams NH_4Cl is produced. The reaction are follows

I. $Mg + \frac{1}{2}O_2 \longrightarrow MgO$,

II. $3Mg + N_2 \longrightarrow Mg_3N_2$

III. $MgO + 2HCl \longrightarrow MgCl_2 + H_2O$,

IV. $Mg_3N_2 + 8HCl \longrightarrow 2NH_4Cl + 3MgCl_2$

Then the moles of $MgCl_2$ formed is : (At. wt. $Mg = 24, N = 14, Cl = 35.5$)

(a) 3 moles (b) 6 moles

(c) 5 moles (d) 10 moles

17. (X) On the left column, some reactions are indicated and on the right column, properties of reactions are described. Match them appropriately, and select the correct code.

	Column I	Column II
(A)	$N_2(5.00g) + H_2(1.00g) \longrightarrow NH_3$	(p) First reactant is the limiting reagent.
(B)	$N_2(3g) + F_2(10g) \longrightarrow N_2F_4$	(q) Mass of reactant = Mass of product
(C)	$S(1.0g) + O_2(1.0g) \longrightarrow SO_2$	(r) Stoichiometric amounts of reactants.
		(s) Second reactant is the limiting reactant.

	p	q	r	s
(a)	B	A	A	C
(b)	B	C	B	A
(c)	B	C	C	A
(d)	C	A	B	C

18. (S) If 7.0 moles of Y is placed in a container and allowed to react with X until equilibrium is reched according to the reaction :

$2X + Y \rightarrow 2Z$

It is found that the equilibrium mixture contains 8.0 moles of X and 5.0 moles of Y. How many moles of X were present in the original container ?

(a) 10 (b) 12

(c) 14 (d) 16

19. (S) Consider the given reversible reaction at equilibrium

$2NO + Cl_2 \rightarrow 2ClNO(g)$

Suppose that 0.30 mol NO, 0.20 mole of Cl_2 and 0.50 mole of ClNO were placed in a 25.00L vessel and allowed to reach the equilibrium. At equilibrium, the concentration of ClNO was found to be 0.024 molar. Molar concentration of NO present at equilibrium is

(a) 0.004 M (b) 0.006 M

(c) 0.008 M (d) 0.01 M

20. (I) A mixture of FeO and Fe_3O_4 when heated in air to a constant weight, gains 5% of its weight. Find the percentage of Fe_3O_4.

21. (I) Igniting MnO_2 in air converts it quantitatively to Mn_3O_4. A sample of pyrolusite is of the following composition : MnO_2 = 80%, SiO_2 and other inert constituents = 15% and rest bearing H_2O. The sample is ignited to constant weight. What is the % of Mn in the ignited sample ?

22. (I) A mixture contains equi-molar quantities of carbonates of two bivalent metals. One metal is present to the extent of 13.5% by weight in the mixture and 2.50 gm of the mixture on heating leaves a residue of 1.18 gm. Calculate the % age by weight of the other metal.

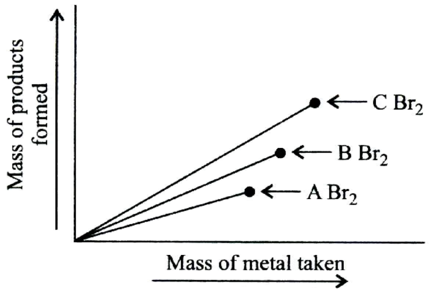
23. (I) A 0.01 moles of sample of $KClO_3$ was heated under such conditions that a part of it decomposed according to the equation :

(a) $2KClO_3 \rightarrow 2KCl + 3O_2$ and the remaining undergoes change according to the equation :

(b) $4KClO_3 \rightarrow 3KClO_4 + KCl$

If the amount of O_2 evolved was 134.4 mL at S.T.P., calculate the % age by weight of $KClO_4$ in the residue.

24. (M) Three metals of alkaline earth metal group (A, B, and C) when reacted with a fixed volume of liquid Br_2 separately gave a product (metal bromides) whose mass is plotted against the mass of metals taken as shown in the figure.



From the plot, predict what relation can be concluded between the atomic weights of A, B, and C ?

(a) C > B

(b) B > A

(c) C < A < B

(d) Data is insufficient to predict

25. (I) One commercial system removes SO_2 emission from smoke at 95ºC by the following set of reaction :

$$SO_2(g) + Cl_2(g) \longrightarrow SO_2Cl_2(g)$$

$$SO_2Cl_2(g) + H_2O(l) \longrightarrow H_2SO_4 + HCl$$

$$H_2SO_4 + Ca(OH)_2 \longrightarrow CaSO_4 + H_2O$$

How many grams of $CaSO_4$ may be produced from 3.78g of SO_2 ?

26. (M) Which of the following statements is/are correct ?

1.0g mixture of $CaCO_3$(s) and glass beads liberate 0.22g of CO_2 upon treatment with excess of HCl. Glass does not react with HCl.

$$CaCO_3 + 2HCl \longrightarrow CO_2 + H_2O + CaCl_2$$

[Mw $CaCO_3$ = 100. Mw of CO_2 = 44, [Atomic weight of Ca = 40]

(a) The weight of $CaCO_3$ in the original mixture is 0.5g.

(b) The weight of calcium in the original mixture is 0.2g.

(c) The weight percent of calcium in the original mixture is 40% Ca.

(d) The weight percent of Ca in the original mixture is 20% Ca.

27. (M) Which of the following statements is/are correct ?

The following reaction occurs :

$$2Al + 3MnO \xrightarrow{\Delta} CCl_4 + S_2Cl_2$$

108.0g of Al and 213.0g of MnO was heated to initiate the reaction . (Mw of MnO = 71, atomic weight of Al = 13)

(a) Al is present in excess.

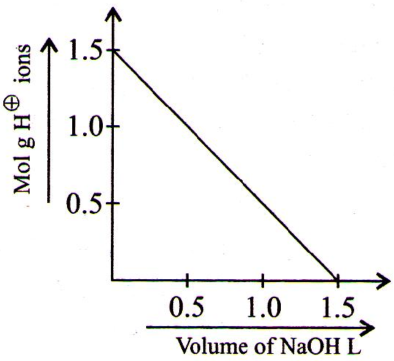
(b) MnO is present is excess.

(c) 54.0g of Al is required.

(d) 159.0g of MnO is in excess.

Percent Purity

28. (S) To 1 L of 1.0 M impure H_2SO_4 sample, 1.0 M NaOH solution was added and a plot was obtained as follows :



The % purity of H_2SO_4 and the slope of curve, respectively, are :

(a) 75%, –1/2 (b) 75%, –1

(c) 50%, –1/3 (d) 50%, –1/2

Percent Yield

29. (S) In the preparation of iron from haematite (Fe_2O_3) by the reaction with carbon

$$Fe_2O_3 + C \longrightarrow Fe + CO_2$$

How much 80% pure iron could be produced from 120 kg of 90% pure Fe_2O_3 ?

(a) 94.5 kg (b) 60.48 kg

(c) 116.66 kg (d) 120 kg

30. (S) NH_3 is formed in the following steps :

I. $Ca + 2C \rightarrow CaC_2$ 50% yield

II. $CaC_2 + N_2 \rightarrow CaCN_2 + C$ 100% yield

III. $CaCN_2 + 3H_2O \rightarrow 2NH_3 + CaCO_3$ 50% yield

To obtain 2 mol NH_3, calcium required is :

(a) 1 mol (b) 2 mol

(c) 3 mol (d) 4mol

Strength : Mass Percent

31. (S) If 100 m*l* of H_2SO_4 (A) and 100 m*l* of H_2O (B) are mixed. Then the mass per cent of H_2SO_4 would be (Given density of H_2SO_4 = 0.9 g/m*l*; density of H_2O = 1.0 g/m*l*)

(a) 60 (b) 50

(c) 47.36 (d) 90

32. (S) If 100 mL of H_2SO_4 and 100 mL of H_2O are mixed, the mass percent of H_2SO_4 in the resulting solution is

$(d_{H_2SO_4} = 0.09 g\ mL^{-1}, d_{H_2O} = 1.0 g\ mL^{-1})$

(a) 90 (b) 47.36

(c) 50 (d) 60

Strength : Molality

33. (A) **Assertion :** Molality and mole fraction units of concentration do not change with temperature.

Reason : These concentration units are defined in terms of mass rather in terms of volume and mass is independent of temperature.

(a) A (b) B

(c) C (d) D

34. (M) Select dimensionless quantity(ies) :

(a) vapour density (b) molality

(c) specific gravity (d) mass fraction

Comprehension

HNO_3 used as a reagent has specific gravity of 1.42g mL^{-1} and contains 70% by strength HNO_3.

35. (C) Normality of acid is.

(a) 16.78 (b) 15.78

(c) 14.78 (d) 17.78

36. (C) Volume of acid that contains 63g pure acid is.

(a) 100 mL (b) 40.24 mL

(c) 63.38 mL (d) 70.68 mL

37. (C) Volume of water required to make 1N solution from 2 mL conc. HNO_3.

(a) 29.56 mL (b) 30.56 mL

(c) 28.56 mL (d) 31.56 mL

38. (S) An aqueous solution of glucose ($C_6H_{12}O_6$) is 0.01 M. To 200 mL of this solution, which of the following should be carried out to make it 0.02 M ?

I. Evaporate 50 m*l* of solution

II. Add 0.180 gm of glucose

III. Add 50 mL of water

The correct option is :

(a) I (b) II

(c) I, II (d) I, II, III

39. (S) Equal volumes of 0.200 M HCl and 0.400M KOH are mixed. The concentrations of the ions in the resulting solution are :

(a) $[K^+] = 0.40M, [Cl^-] = 0.20 M, [H^+] = 0.20 M$

(b) $[K^+] = 0.20 M, [Cl^-] = 0.10 M, [OH^-] = 0.10 M$

(c) $[K^+] = 0.10 M, [Cl^-] = 0.10 M, [OH^-] = 0.10 M$

(d) $[K^+] = 0.20 M, [Cl^-] = 0.10 M, [OH^-] = 0.20 M$

40. (M) You are provided with 1 M solution of $NaNO_3$ whose density = 1.25 g/ml

(a) The percentage by mass of $NaNO_3$ = 6.8

(b) The percentage by mass of H_2O = 93.2

(c) The molality of the solution is 10.72

(d) The solution has 0.2 moles of $NaNO_3$.

41. (A) **Assertion :** In laboratory, reagents are made to a specific molarity rather molality.

Reason : The volume of sulution is easier to measure than its mass.

(a) A (b) B

(c) C (d) D

COMPREHENSION

The analytical molarity of a solution gives the total number of moles of a solute in one litre of the solution. The equilibrium molarity represents the molar concentration of particular species in a solution at equilibrium. In order to specify the equilibrium molarity of a particular species it is necessary to know how the solute behaves when it is dissolved in a solvent. e.g., if analytical molarity of HC*l* is 0.1 M then equilibrium molarity of NaOH equal to zero because HC*l* is completely dissociated.

42. (C) Calculate the analytical molarity of Cl^- ion in solution which is prepared by mixing 100 m*l* of 0.1 M NaC*l* and 400 m*l* of 0.01 M $BaCl_2$.

(a) 0.018 M (b) 0.036 M

(c) 0.084 M (d) 0.046 M

43. (C) The molarity of 68 % of H_2SO_4 whose density is 1.84 g/cc is

(a) 12.76 M (b) 6.84 M

(c) 18.4 M (d) 6.8 M

44. (C) HC*l* is 80% ionised in 0.01 M aqueous solution. The equilibrium molarity of HC*l* in the solution is

(a) 0.002 (b) 0.06

(c) 0.02 (d) 0.008

45. (M) Which of the following statements is/are correct ?

20.0 mL of 6.0 M HCl is mixed with 50.0 mL of 2.0 M $Ba(OH)_2$, and 30 mL of water is added.

(a) The concentration $\overset{\ominus}{O}H$ remaining in solution is 0.8 M.

(b) The concentration of $Cl^{\ominus}$ remaining in solution is 1.2 M.

(c) The concentration of Ba^{2+} remaining in solution is 1.0M

(d) 80 mmoles of $\overset{\ominus}{O}H$ is in excess.

46. (M) The density of a solution of H_2SO_4 is 1.84 gm/ml and it contain 93% H_2SO_4 by volume. Then

(a) Molarity of H_2SO_4 is 10.42

(b) Mass of H_2O = 91 gm

(c) Mass of 100 gm solution = 184 gm

(d) None of the above

Strength : Mole Fraction

47. (M) The mole fraction of NaCl in aqueous solution is 0.2. The solution is

(a) 13.9 m

(b) Mole fraction of H_2O is 0.8

(c) acidic in nature

(d) neutral

Strength : Variation

48. (M) When 100 ml of 0.1 M KNO_3, 400 ml of 0.2 M HCl and 500 ml of 0.3 M H_2SO_4 are mixed. Then in the resulting solution

(a) The molarity of K^+ = 0.01 M

(b) The molarity of SO_4^{2-} = 0.15 M

(c) The molarity of H^+ = 0.38 M

(d) The molarity of NO_3^- = 0.01 M and Cl^- = 0.08 M

49. (A) **Assertion :** Molality of solution is independent of temperature while mole fraction depends on temperature.
Reason : Normality is the ratio of moles of solute and volume of solution while mole fraction is the ratio of moles of solute and weight of solvent present in solution.

(a) A (b) B

(c) C (d) D

50. (A) **Assertion :** When a solution is diluted from volume V_1 to V_2 by adding solvents, its molarity before dilution M_1 and after dilution M_2 are related as :

$M_1V_1 = M_2V_2$

Reason : During dilution, moles of the solute remains conserved.

(a) A (b) B

(c) C (d) D

51. (A) **Assertion :** For a binary solutiokn of two liquids, A and B, with the knowledge of density of solution, molarity can be converted into molality.

Reason : Molarity is defined in terms of volume and molality in terms of mass, and mass and volume are related by density.

(a) A (b) B

(c) C (d) D

52. (I) 50 mL of 1 M HCl, 100 mL of 0.5 M HNO_3, and x mL of 5 M H_2SO_4 are mixed together and the total volume is made upto 1.0 L with water. 100 mL of this solution exactly neutralises 10 mL of M/3 $Al_2(CO_3)_3$. Calculate the value of x.

53. (I) HCl gas is passed into water, yielding a solution of density 1.095 g mL^{-1} and containing 30% HCl by weight. Calculate the molarity of the solution.

54. (I) A solution contains 75 mg NaCl per mL. To what extent must it be diluted to give a solution of concentration 15 mg NaCl per mL of solution.

Strength : Stoichiometric Calculations

55. (S) How much $NaNO_3$ must be weighed out to make 50 ml of an aqueous solution containing 70 mg of Na^+ per m*l*?

(a) 12.394 g (b) 1.29 g
(c) 10.934 g (d) 12.934 g

56. (S) 11.4 gm of a mixture of butene, C_4H_8 and butane C_4H_{10}, was burned in excess oxygen. 35.2 gm of CO_2 and 16.2 gm of H_2O were obtained. Calculate the percentage by mass of butane in original mixture.

(a) 50.87% (b) 49.13%
(c) 50% (d) None of these

57. (X) Match the solution mixtures given in column I with the concentrations given in column II.

Column I	Column II
(a) 11.1 g $CaCl_2$ and 29.25g of NaCl are diluted with water to 100 mL	(p) $[Ca^{2+}] = 0.8$ M, $[Na^{\oplus}] = 1.2$ M, $[Cl^{\ominus}] = 2.8$ M
(b) 3.0 L of 4.0 M NaCl and 4.0 L of 2.0 M $CaCl_2$ are combined and diluted to 10.0 L	(q) $[Ca^{2+}] = 0.001$ M, $[Na^{\oplus}] = 0.005$ M, $[Cl^{\ominus}] = 0.007$ M
(c) 3.0 L of 3.0 M NaCl is added to 200 mL of 4.0 M $CaCl_2$	(r) $[Ca^{2+}] = 1.6$ M, $[Na^{\oplus}] = 1.8$ M, $[Cl^{\ominus}] = 5.0$ M
(d) 100 mL of 2.0 M HCl +200 mL of 1.0 M NaOH +150 mL of 4.0 M $CaCl_2$ +50 mL of H_2O	(s) $[Ca^{2+}] = 1.2$ M, $[Na^{\oplus}] = 0.4$ M, $[Cl^{\ominus}] = 2.8$ M

58. (S) 100 mL of mixture of NaOH and Na_2SO_4 is neutralised by 10 mL of 0.5 M H_2SO_4. Hence, NaOH in 100 mL solution is

(a) 0.2 g (b) 0.4 g
(c) 0.6 g (d) None

59. (S) $BrO_3^{\ominus} + 5Br^{\ominus} \longrightarrow Br_2 + 3H_2O$

If 50 mL 0.1 M $BrO_3^{\ominus}$ is mixed with 30 mL of 0.5 M $Br^{\ominus}$ solution that contains excess of $H^{\oplus}$ ions, the moles of Br_2 formed are

(a) 6.0×10^{-4} (b) 1.2×10^{-4}
(c) 9.0×10^{-3} (d) 1.8×10^{-3}

Molar Volume of Gas based Calculations

60. (S) 1 g alloy of Cu and Zn reacted with excess of dil. H_2SO_4 to give H_2 gas which occupies 60 m*l* at STP. The percentage of Zn in the alloy (Given only Zn reacts with H_2SO_4)

(a) 17% (b) 34%
(c) 83% (d) 40%

61. (S) A solution of NaOH is prepared by dissolving 4.0 g of NaOH in 1 L of water. Calculate the volume of the HC*l* gas at STP that will neutralize 50 mL of this solution.

(a) 224 mL (b) 56 mL
(c) 112 mL (d) 448 mL

62. (M) 11.2 L of a gas at STP weighs 14 g. The gas could be :

(a) N_2 (b) CO
(c) NO_2 (d) N_2O

Empirical Formula

63. (M) An oxide of nitrogen has 30.43% nitrogen (At. wt. of N=14) and its one molecule weight 1.527×10^{-22} g. Which of the following statement regarding the oxide is (are) true ?

(a) Its empirical formula is N_2O

(b) Its empirical formula is NO_2.

(c) Its molecular formula is N_2O_4.

(d) Its molecular formula is N_4O_2.

Comprehension

A crystalline hydrated salt on being rendered anhydrous loses 45.6% of its weight.

The percentage composition of anhydrous salt is : Al = 10.5%, K = 15.1 %, S = 24.8% and oxygen = 49.6% Answer the following four questions based on these information. [Molar masses are : Al = 27, K = 39, S = 32]

64. (C) What is the empirical formula of the salt ?

(a) $K_2AlS_2O_7$ (b) $K_2Al_2S_2O_7$

(c) $KAlS_2O_8$ (d) $K_3AlS_2O_{12}$

65. (C) What is the empirical formula of the hydrated salt ?

(a) $K_2AlS_2O_7.10H_2O$ (b) $K_2Al_2S_2O_7.16H_2O$

(c) $K_3AlS_2O_{12}.8H_2O$ (d) $KAlS_2O_8.12H_2O$

66. (C) If 50 g of the above hydrated salt is dissolved in 150 gram of water, molality of the resulting solution will be

(a) 0.7 (b) 0.6

(c) 0.5 (d) 0.4

67. (S) The percentage of Fe in Fe^{3+} in $Fe_{0.93}O_{1.00}$ is

(a) 15.0% (b) 84.2%

(c) 16.98% (d) 18.49 %

68. (S) When a hydrate of Na_2CO_3 is heated until all the water is removed, it loses 543 per cent of its mass. The formula of the hydrate is

(a) $Na_2CO_3.10H_2O$ (b) $Na_2CO_3.7H_2O$

(c) $Na_2CO_3.5H_2O$ (d) $Na_2CO_3.3H_2O$

Laws of Chemical Combination

69. (S) Two elements X and Y have atomic weights of 14 and 16. They form a series of compounds A, B, C D and E in which for the same amount of element X, Y is present in the ratio 1 : 2 : 3 : 4 : 5. If the compound A has 28 parts by weight of X and 16 parts by weight of Y, then the compound C will have 28 parts by weight of X and

(a) 32 parts by weight of Y

(b) 48 parts by weight of Y

(c) 64 parts by weight of Y

(d) 80 parts by weight of Y

70. (S) One part of an element A combines with two parts of B (another element). Six parts of element C combine with four parts of element B. If A and C combine together, the ratio of their masses will be governed by :

(a) law of definite proportions

(b) law of multiple proportions

(c) law of reciprocal proportions

(d) law of conservation of mass

71. (S) Zinc sulphate contains 22.65% Zn and 43.9% H_2O. If the law of constant proportions is true, then the mass of zinc required to give 40g crystals will be :

(a) 90.6 g (b) 9.06 g

(c) 0.906 g (d) 906 g

72. (S) 3 g of a hydrocarbon on combustion in excess of oxygen produces 8.8g of CO_2 and 5.4 g of H_2O. The data illustrates the law of :

(a) conservation of mass (b) multiple proportions

(c) constant proportions (d) reciporcal proportions

73. (S) Potassium combines with two isotopes of chlorine (^{35}Cl and ^{37}Cl) respectively to form two samples of KCl. Their formation follows the law of :

(a) constant proportions (b) multiple proportions

(c) reciprocal proportions

(d) none of these.

Principle of Atom Conservation

74. (S) 2.76 g of silver carbonate on being strongly heated yields a residue weighing

(a) 2.16 g (b) 2.48 g

(c) 2.32 g (d) 2.64 g

75. (I) Igniting MnO_2 in air converts it quantitatively to Mn_3O_4. A sample of pyrolusite is of the following composition : MnO_2 = 80%, SiO_2 and other inert constituents = 15%, and rest bearing H_2O. The sample is ignited to constant weight. What is the percent of Mn in the ignited sample ?

76. (S) How many moles of ferric alum

$(NH_4)_2SO_4Fe_2(SO_4)_3 . 24H_2O$ can be made from the sample of Fe containing 0.0056 g of it ?

(a) 10^{-4} mol (b) 0.5×10^{-4} mol

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

77. (I) A sample of a mixture of $CaCl_2$ and NaCl weighing 4.22g was treated to precipitate all the Ca as $CaCO_3$, which was then heated and quantitatively converted to 0.959g of CaO. Calculate the percentage of $CaCl_2$ in the mixture.

(Ca = 40, O = 16, C = 12 and Cl = 35.5)

Equivalent Concept

78. (S) A metal oxide has the formula Z_2O_3. It can be reduced by hydrogen to give free metal and water. 0.16 gm of the metal oxide requires 6 mg of hydrogen for complete reduction. The atomic weight of the metal is :

(a) 27.9 (b) 159.6

(c) 79.8 (d) 55.8

79. (M) For the reaction

$$H_3PO_4 + Ca(OH)_2 \longrightarrow CaHPO_4 + 2\,H_2O$$

1 mol 1 mol

Which are true statements?

(a) Equivalent weight of H_3PO_4 is 49

(b) Resulting mixture is neutralised by 1 mol of KOH

(c) $CaHPO_4$ is an acidic salt

(d) 1 mol of H_3PO_4 is completely neutralized by 1.5 mol of $Ca(OH)_2$

80. (A) **Assertion :** 1mole of H_2SO_4 is neutralised by 2 moles of NaOH but 1 equivalent of H_2SO_4 is neutralised by 1 equivalent of NaOH.

Reason : Equivalent weight of H_2SO_4 is half of its molecular weight while equivalent weight of NaOH is 40.

(a) A (b) B

(c) C (d) D

81. (A) **Assertion :** Equivalent volume of H_2 is 11.2 L at 1 atm and 273 K.

Reason : 1/2 mole H^2 has produced when 1 mole of H^+(aq) accepted 1 mole of e^-.

(a) A (b) B

(c) C (d) D

82. (A) **Assertion (A) :** The equivalent mass of an element is variable.

Reason (R) : It depends on the valency of the element.

(a) A (b) B

(c) C (d) D

83. (S) $N_2 + 3H_2 \rightarrow 2NH_3$

Molecular weight of NH_3 and N_2 are x_1 and x_2, respectively. Their equivalent weights are y_1 and y_2, respectively. Then $(y_1 - y_2)$ is

(a) $\left(\frac{2x_1 - x_2}{6}\right)$ (b) $(x_1 - x_2)$

(c) $(3x_1 - x_2)$ (d) $(x_1 - 3x_2)$

84. (S) The vapour density of a chloride of an element is 39.5. The Ew of the elements is 3.82. The atomic weight of the element is

(a) 15.28 (b) 7.64

(c) 3.82 (d) 11.46

85. (M) Which of the following statements regarding the compound A_xB_y is/are correct ?

(a) 1 mole of A_xB_y contains 1 mole of A and 1 mole B

(b) 1 equivalent of A_xB_y contains 1 equivalent of A and 1 equivalent of B

(c) 1 mole of A_xB_y contains x moles of A and y moles of B

(d) equivalent weight of A_xB_y = equivalent weight of B

86. (M) Which of the statements are true ?

(a) The equivalent weight of $Ca_3(PO_4)_2$ is Mw/6.

(b) The equivalent weight of $Na_3PO_4 . 12H_2O$ is Mw/3.

(c) The equivalent weight of K_2SO_4 is Mw/2.

(d) The equivalent weight of potash alum $K_2SO_4Al_2(SO_4)_3 . 24H_2O$ is Mw/8.

Normality

87. (S) 10 mL of N/2 HCl, 20 mL of N/2 H_2SO_4 and 30 mL N/3 HNO_3 are mixed together and solution made to one litre. The normality of the resulting solution is

(a) 0.20 N (b) 0.10 N

(c) 0.50 N (d) 0.025 N

88. (S) 0.115 g of pure sodium metal was dissolved in 500 ml distilled water. The normality of the above solution, whose resulting volume is 400 mL, would be

(a) 0.010 N (b) 0.0115 N

(c) 0.0125 N (d) 0.046 N

89. (S) 50 ml of 10 N H_2SO_4, 25 ml of 12 N HCl and 40 ml of 5N HNO_3 were mixed together and the volume of the mixture was made 1000 ml by adding water. The normality of the resulting solution will be

(a) 1 N (b) 2 N

(c) 3 N (d) 4 N

90. (S) Which of the following 1 g L^{-1} solution has the highest normality ?

(a) NaOH (b) H_2SO_4

(c) HCl (d) HNO_3

91. (A) **Assertion :-** 0.1 M H_3PO_3 (aq) solution has normality equal to 0.3N when completely reacted with NaOH.

Reason : H_3PO_3 is dibasic acid.

(a) A (b) B

(c) C (d) D

92. (X) Match the items given in column I with those in column II.

	Column I	Column II
(a)	9.8% H_2SO_4 by weight (density = 1.8g mL^{-1})	(p) 3.6 N
(b)	9.8 % H_3PO_4 by weight (density = 1.2g mL^{-1})	(q) 1.2 M
(c)	1.8 N_A molecules of HCl is 500 mL	(r) 1.8 Equivalents
(d)	250 mL of 4N NaOH + 250 mL of 1.6 M $Ca(OH)_2$	(s) 1.10 m

93. (S) 10 mL of 0.2 N HCl and 30 mL of 0.1 N HCl together exactly neutralises 40 mL of solution of NaOH, which is also exactly neutralised by a solution in water of 0.61 g of an organic acid.What is the equivalent weight of the organic acid ?

(a) 61 (b) 91.5

(c) 122 (d) 183

94. (M) 1 gm Mg sample is treated with 125 ml 0.1 N HCl and the excess of HCl is neutralised by 50 ml 0.5 N NaOH completely. The correct statement is/are :

(a) Mass of Mg present in the sample is 0.12 gm

(b) Mass of Mg sample unreacted is 0.88 gm

(c) % of Mg present in the sample is 12%

(d) Mass of impurities present in the sample is 0.88 gm.

95. (X) **Match the Column**

	Column		Column
(a)	20 ml (N) HCl reacts with 50 mL $\frac{N}{5}$ NaOH.	(p)	No. of molecules of HCl left = 0
(b)	10 ml $\frac{N}{2}$ HCl reacts with 50 ml $\frac{N}{10}$ NaOH.	(q)	No. of molecules of HCl left = 6.02×10^{21}
(c)	50 ml $\frac{N}{10}$ HCl reacts with 100 ml $\frac{N}{50}$ NaOH.	(r)	No. of molecules of HCl left = 2.71×10^{22}
(d)	100 ml $\frac{N}{2}$ HCl reacts with 50 ml $\frac{N}{10}$ NaOH.	(s)	No. of molecules of HCl left = 1.8×10^{21}

96. (M) An aqueous solution of phosphoric acid (H_3PO_4) being titrated has molarity equal to 0.25 M. Which of the following could be normality of this solution ?

(a) 0.25 N (b) 0.50 N

(c) 0.75 N (d) 1.00 N

97. (M) An aqueous solution of 6.3g of a hydrated oxalic acid ($H_2C_2O_4.xH_2O$) is made up to 250 mL. The 40 mL of 0.10 N NaOH was required to completely neutralize 10mL of the above prepared stock solution. Which of the following statements(s) about is (are) correct ?

(a) The acid is dehydrate.

(b) Equivalent weight of the hydrated acid is 45.

(c) Equivalent weight of the anhydrous acid is 45.

(d) 20 mL of the same stock would require 40 mL of 0.10 M Ca(OH)2 solution for complete neutralization.

EXERCISE - 4 : PREVIOUS YEAR JEE ADVANCED QUESTION

1. Dissolving 120g of urea (mol. wt. 60) in 1000g of water gave a solution of density 1.15 g/mL. The molarity of the solution is **(2011)**

(a) 1.78 M (b) 2.00 M

(c) 2.05 M (d) 2.22 M

2. Given that the abundances of isotopes $_{54}Fe$, $_{56}Fe$ and $_{57}Fe$ are 5%, 90% and 5%, respectively, the atomic mass of Fe is **(2009)**

(a) 55.85 (b) 55.95

(c) 55.75 (d) 56.05

3. 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 solution.

1 L of mixture X + excess of $AgNO_3$ solution $\rightarrow$ Y

1 L of mixture X + excess of $BaCl_2$ solution $\rightarrow$ Z

Number of moles of Y and Z are **(2003)**

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

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

4. Which has maximum number of atoms ? **(2003)**

(a) 24g of C (12) (b) 56g of Fe (56)

(c) 27g of Al (27) (d) 108g of Ag (108)

5. How many moles of electron weighs one kilogram ?

(a) 6.023×10^{23} (b) $\frac{1}{9.108} \times 10^{31}$

(c) $\frac{6.023}{9.108} \times 10^{54}$ (d) $\frac{1}{9.108 \times 6.023} \times 10^{8}$

6. 6.3g of oxalic acid dihydrate have been dissolved in water to obtain a 250 mL solution. How much volume of 0.1 N NaOH would be required to neutralise 10 mL of this solutions ? **(2001)**

(a) 40 mL (b) 20 mL

(c) 10 mL (d) 4 mL

7. The normality of 0.3 M phosphorous acid (H_3PO_3) is **(1999)**

(a) 0.1 (b) 0.9

(c) 0.3 (d) 0.6

8. The weight of 1×10^{22} molecules of $CuSO_4 . 5H_2O$ is **(1991)**

(a) 41.59 g (b) 415.9g

(c) 4.159 g (d) none of the three

9. The sulphate of a metal M contains 9.87% of M. This sulphate is isomorphous with $ZnSO_4.7H_2O$. The atomic weight of M is **(1991)**

(a) 40.3 (b) 36.3

(c) 24.3 (d) 11.3

10. If 0.5 mol of $BaCl_2$ is mixed with 0.2 mol of Na_3PO_4, the maximum number of moles of $Ba_3(PO_4)_2$ that can be formed is **(1981)**

(a) 0.7 (b) 0.5

(c) 0.30 (d) 0.10

11. The total number of electrons present in 18 ml of water (density of water is 1 g ml^{-1}) is **(1980)**

(a) 6.02×10^{23} (b) 6.02×10^{23}

(c) 6.02×10^{24} (d) 6.02×10^{25}

12. 29.2% (w/W) HCl stock solution has density of 1.25 g mL^{-1}. The molecular weight of HCl is 36.5g mol^{-1}. The volume (mL) of stock solution required to prepare a 200 mL solution 0.4 M HCl is **(2013)**

13. 20% surface sites have adsorbed N_2. On heating N_2 gas evolved from sites and were collected at 0.001 atm and 298 K in a container of volume is 2.46 cm^3. Density of surface sites is $6.023 \times 10^{14}/cm^2$ and surface area is 1000 cm^2, find out the number of surface sites occupied per molecule of N_2. **(2005)**

14. A compound H_2X with molar weight of 80g is dissolved in a solvent having density of 0.4 g ml^{-1}. Assuming no change in volume upon dissolution, the molality of a 3.2 molar solution is **(2014)**

15. The mole fraction of a solute in a solution in 0.1 At 298K, molarity of this solution is the same as its molality. Density of this solution at 298 K is 2.0 g cm^{-3}. The ratio of the molecular weights of the solute and solvent, $\left(\frac{MW_{solute}}{MW_{solvent}}\right)$, is **(2016)**

16. In a solution of 100 mL 0.5 M acetic acid, one gram of active charcoal is added, which adsorbs acetic acid. It is found that the concentration of acetic acid becomes 0.49 M. If surface area of charcoal is $3.01 \times 10^2 m^2$, calculate the area occupied by single acetic acid molecule on surface of charcoal. **(2003)**

17. Calculate the molarity of water if its density is 1000 kg/m^3. **(2003)**

18. 3 g of a salt of molecular weight 30 is dissolved in 250 g of water. The molality of the solution is : .... **(1983)**

19. The weight of 1×10^{22} molecules of $CuSO_4 \cdot 5H_2O$ is : .... **(1991)**

20. A sugar syrup of weight 214.2 g contains 34.2 g of sugar ($C_{12}H_{22}O_{11}$). Calculate : (i) molal concentration and (ii) mole fraction of sugar in the syrup. **(1988)**

21. Galena (an ore) is partially oxidized by passing air through it at high temperature. After some time, the passage of air is stopped, but the heating is continued in a closed furnace such that the contents undergo self-reduction. The weight (in kg) of Pb produced per kg of O_2 consumed is ....

(Atomic weights in g mol^{-1} : O = 16, S = 32, Pb = 207)

(2018)

ANSWER KEY

Exercise-1 : (Basic Objective Questions)

1. (b)	**2.** (b)	**3.** (b)	**4.** (a)	**5.** (b)	**6.** (a)	**7.** (c)	**8.** (b)	**9.** (d)	**10.** (a)
11. (b)	**12.** (d)	**13.** (a)	**14.** (a)	**15.** (a)	**16.** (b)	**17.** (d)	**18.** (d)	**19.** (a)	**20.** (c)
21. (b)	**22.** (d)	**23.** (a)	**24.** (c)	**25.** (c)	**26.** (b)	**27.** (c)	**28.** (a)	**29.** (b)	**30.** (a)
31. (a)	**32.** (c)	**33.** (a)	**34.** (b)	**35.** (b)	**36.** (c)	**37.** (d)	**38.** (a)	**39.** (a)	**40.** (b)
41. (d)	**42.** (c)	**43.** (d)	**44.** (b)	**45.** (b)	**46.** (c)	**47.** (c)	**48.** (c)	**49.** (c)	**50.** (b)
51. (d)	**52.** (d)	**53.** (b)	**54.** (d)	**55.** (c)	**56.** (c)	**57.** (d)	**58.** (d)	**59.** (a,b)	**60.** (c)
61. (d)	**62.** (d)	**63.** (c)	**64.** (b)	**65.** (a)	**66.** (a)	**67.** (c)	**68.** (c)	**69.** (b)	**70.** (b)
71. (c)	**72.** (a)	**73.** (d)	**74.** (a)	**75.** (b)	**76.** (d)	**77.** (c)	**78.** (c)	**79.** (a)	**80.** (a)
81. (c)	**82.** (b)	**83.** (a)	**84.** (b)	**85.** (a)	**86.** (d)	**87.** (b)	**88.** (b)	**89.** (a)	**90.** (b)
91. (b)	**92.** (d)	**93.** (d)	**94.** (c)						

Exercise - 2 : (Previous Year JEE Mains Questions)

1. (a)	**2.** (a)	**3.** (c)	**4.** (c)	**5.** (d)	**6.** (b)	**7.** (a)	**8.** (b)
9. (d)	**10.** (b)	**11.** (c)	**12.** (a)	**13.** (c)	**14.** (d)	**15.** (a)	**16.** (a)
17. (a)	**18.** (c)	**19.** (c)	**20.** (b)	**21.** (a)	**22.** (a)		

JEE Mains Online

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

Exercise - 3 : (Advanced Objective Questions)

1. (c)	**2.** (a)	**3.** (c)	**4.** (A)$\rightarrow$ (R)(B)$\rightarrow$ (P,S),(C)$\rightarrow$ (Q),(D)$\rightarrow$ (P),(S)				**5.** (a)
6. (c)	**7.** (b)	**8.** (bc)	**9.** (ab)	**10.** (d)	**11.** (b)	**12.** (d)	**13.** (bc)
14. (a)	**15.** (d)	**16.** (c)	**17.** (c)	**18.** (b)	**19.** (c)	**20.** (0080)	**21.** (0059)
22. (0014)	**23.** (0060)	**24.** (a,b)	**25.** (0008)	**26.** (abd)	**27.** (ac)	**28.** (b)	**29.** (a)
30. (d)	**31.** (c)	**32.** (b)	**33.** (a)	**34.** (a,c,d)	**35.** (b)	**36.** (c)	**37.** (a)
38. (c)	**39.** (d)	**40.** (a,b)	**41.** (a)	**42.** (b)	**43.** (a)	**44.** (a)	**45.** (abcd)
46. (abc)	**47.** (abd)	**48.** (a,b,c,d)	**49.** (d)	**50.** (a)	**51.** (d)	**52.** (0010)	**53.** (0009)
54. (0005)	**55.** (d)	**56.** (a)					
57. (a $\rightarrow$ q), (b $\rightarrow$ p), (c $\rightarrow$ r), (d $\rightarrow$ s)			**58.** (b)	**59.** (c)	**60.** (a)	**61.** (c)	**62.** (ab)
63. (bc)	**64.** (c)	**65.** (d)	**66.** (b)	**67.** (a)	**68.** (a)	**69.** (b)	**70.** (c)
71. (b)	**72.** (a)	**73.** (d)	**74.** (a)	**75.** 59.36%	**76.** (b)	**77.** 45.04%	**78.** (d)
79. (abcd)	**80.** (b)	**81.** (a)	**82.** (a)	**83.** (a)	**84.** (b)	**85.** (b,c,d)	**86.** (abcd)
87. (d)	**88.** (c)	**89.** (a)	**90.** (c)	**91.** (d)			
92. (a – p, s; b – p, q, s; c – p, r; d – r)			**93.** (c)	**94.** (abcd)	**95.** (a – q; b – q; c – s; d – r)		
96. (abc)	**97.** (acd)						

Exercise - 4 : (Previous Year JEE Advanced Questions)

1. (c)	**2.** (b)	**3.** (a)	**4.** (a)	**5.** (d)	**6.** (a)	**7.** (d)	**8.** (c)
9. (c)	**10.** (d)	**11.** (c)	**12.** (8)	**13.** (2)	**14.** (8)	**15.** (9)	
16. 5×10^{-19} m^2		**17.** 55.55M	**18.** 0.4m	**19.** 4.14g	**20.** (i) 0.56, (ii) 0.0099		**21.** 6.47

Dream on !!