

MOLE AND EQUIVALENT CONCEPT

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, possess mass and the presence of which can be felt by any one or more of our five senses.

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

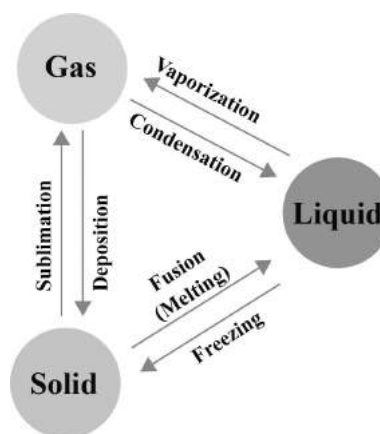
Solid - A substance is said to be solid if it possesses a definite volume and a definite shape, e.g., sugar, iron, gold, wood etc.

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 :

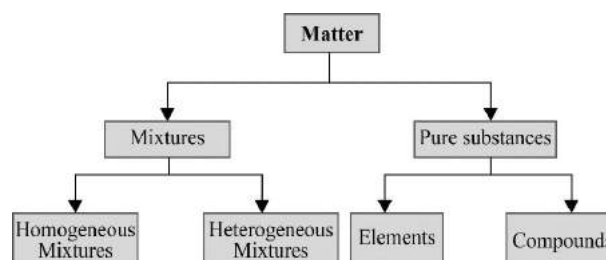


3. CLASSIFICATION OF MATTER AT

MACROSCOPIC LEVEL

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 consists 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 et Mesures). 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, hence called derived quantities. The definitions of the SI base units are given

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 international 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	<ol style="list-style-type: none"> 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. This is the international prototype 1 kg. **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 — $^{\circ}\text{C}$ (degree celsius), $^{\circ}\text{F}$ (degree fahrenheit) and K (kelvin). The temperature on two scales is related to each other by the following relationship:

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

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

7. LAW OF CHEMICAL COMBINATION

7.1 Law of conservation of mass

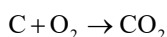
“In a chemical reaction the mass of reactants consumed and mass of the products formed is same, that is mass is conserved.” This is a direct consequence of law of conservation of atoms. This law was put forth by **Antoine Lavoisier** in 1789. For example, 12 g of carbon combines with 32 g of oxygen to form 44 g of CO_2 .

7.2 Law of Constant / Definite Proportions

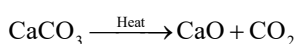
The ratio in which two or more elements combine to form a compound remains fixed and is independent of the source of the compound. This law was given by, a French chemist, **Joseph Proust**.

For example, carbon dioxide can be obtained by a number of methods, such as

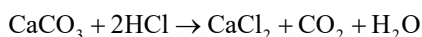
- (i). By burning coal or candle



- (ii). By heating limestone (CaCO_3)



- (iii). By the action of dilute hydrochloric acid on marble peices.



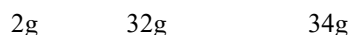
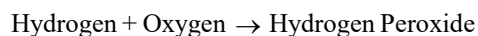
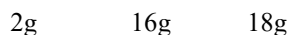
It has been observed that each sample of carbon dioxide contains carbon and oxygen elements in the ratio of 3 : 8 by weight.

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.

For example,

Hydrogen combines with oxygen to form two compounds namely water and hydrogen peroxide.



Therefore, the masses of oxygen (16g or 32g) which combine with fixed mass of hydrogen (2 parts) bear a simple ratio i.e., 16 : 32 or 1 : 2.

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.

For example,

Consider 3 grams of C reacting with 1 g of H to form methane. Also, 8 g of O reacting with 1 g of H to form water. Here, the mass ratio of carbon and oxygen is 3:8. Similarly, 12 g of C reacts with 32 g of O to form CO_2 . The mass ratio of carbon and oxygen is 12:32 = 3:8.

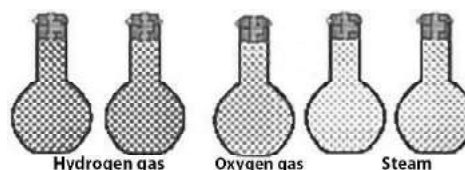
The mass ratio in which C and O combine with each other is the same as the mass ratio in which they separately combine with a fixed mass of H.

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.

For example,

Two volumes of hydrogen combine with one volume of oxygen to give two volumes of water vapour.



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.

For example,

The deflation of automobile tyres. When the air trapped inside the tyre escapes, the number of moles of air present in the tyre decreases. This results in a decrease in the volume occupied by the gas, causing the tyre to lose its shape and deflate.

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 and properties.
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.

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

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.

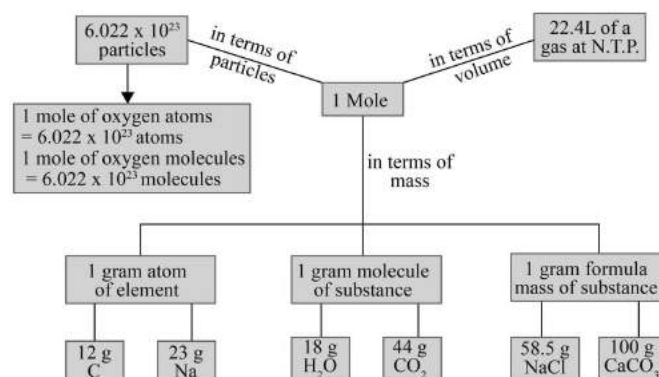
6.022×10^{23} is also called 1 mole of atoms and this number is also called the **Avogadro's Number**.

Mole is just a number. As 1 dozen = 12; 1 million = 10^6 ; 1 mole = 6.022×10^{23} .

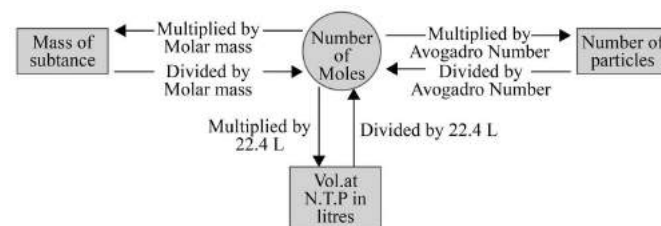
10. MOLECULES

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.



Various relationships of mole



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 sum of masses of reactant 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 (LR)** and the reactant present in excess is called the **Excess Reagent (ER)**. 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 or concentration of a solution are:

- **Mole fraction (X)** : moles of a component / Total moles of solution.

- **Mass%** : Mass percentage is defined as the ratio of the mass of the solute in g to the mass of solution in g multiplied by 100.

- **Mass/Vol %** : It is defined as the ratio of the mass of the solute in g to the volume of the solution in ml multiplied by 100.

- **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 of solute 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

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

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:

$$M_1 V_1 = \text{moles of solute in the solution} = M_2 V_2$$

(M_2 = final molarity)

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. 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 was 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+} .

18. 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.

18.1 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.”

18.2 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.

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

18.3 Equivalent Mass

It is the number of parts by weight of the substance that combines or displaces, directly or indirectly, 1.008 parts by mass of hydrogen or 8 parts by mass of oxygen or 35.5 parts by mass of chlorine. It can be calculated as:

$$(i) \quad \text{Equivalent mass for elements} = \frac{\text{Atomic mass}}{\text{Valency}}$$

$$(ii) \quad \text{Equivalent mass for acids} = \frac{\text{Molecular mass}}{\text{Basicity of acids}}$$

• Basicity: It is the number of H^+ ions that can be displaced from one molecule of a substance.

$$(iii) \quad \text{Equivalent mass for bases} = \frac{\text{Molecular mass}}{\text{Acidity of Base}}$$

• Acidity: It is the number of OH^- ions that can be displaced from one molecule of a substance.

$$(iv) \quad \text{Equivalent mass for salts}$$

$$= \frac{\text{Formula mass}}{(\text{Valency of cation})(\text{No. of cations})}$$

$$(v) \quad \text{Equivalent mass for oxidising agents}$$

$$= \frac{\text{Formula mass}}{\text{No. of electrons gained per molecule}}$$

$$(vi) \quad \text{Equivalent mass for reducing agents}$$

$$= \frac{\text{Formula mass}}{\text{No. of electrons lost per molecule}}$$

$$(vii) \quad \text{Equivalent weight of radicals}$$

$$= \frac{\text{Formula mass}}{\text{No. of units of charge}}$$

NOTE

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

19. 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.

20. 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 1 eq. of D.

21. 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 is the total amount of positive or negative charge furnished by 1 mol of the salt.

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 \times Volume (L)**.

On dilution of the solution the number of equivalents of the solute is conserved and thus, we can apply the formula : $N_1 V_1 = N_2 V_2 = \text{equivalents of solute in solution}$

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

$N = M \times Z$; where 'Z' is the Valency factor

SUMMARY

- All substances contain matter, which can exist in three states – solid, liquid or gas. The constituent particles are held in different ways in these states of matter and they exhibit their characteristic properties. Matter can also be classified into elements, compounds or mixtures. An **element** contains particles of only one type, which may be **atoms** or **molecules**. The compounds are formed where atoms of two or more elements combine in a fixed ratio to each other. Mixtures occur widely and many of the substances present around us are mixtures.
- When the properties of a substance are studied, measurement is inherent. The quantification of properties requires a system of measurement and units in which the quantities are to be expressed. Many systems of measurement exist, of which the English and the Metric Systems are widely used. The scientific community, however, has agreed to have a uniform and common system throughout the world, which is abbreviated as SI units (International System of Units).
- The uncertainty is taken care of by specifying the number of **significant figures**, in which the observations are reported.
- The combination of different atoms is governed by basic laws of chemical combination — these being the **Law of Conservation of Mass, Law of Definite Proportions, Law of Multiple Proportions, Law of Reciprocal Proportion, Gay Lussac's Law of Gaseous Volumes and Avogadro Law**. All these laws led to the **Dalton's atomic theory**, which states that atoms are building blocks of matter.
- The atomic mass of an element is expressed relative to ^{12}C isotope of carbon, which has an exact value of 12u. Usually, the atomic mass used for an element is the **average atomic mass** obtained by taking into account the natural abundance of different isotopes of that element. The **molecular mass** of a molecule is obtained by taking sum of the atomic masses of different atoms present in a molecule. The **molecular formula** can be calculated by determining the mass per cent of different elements present in a compound and its molecular mass.
- The number of atoms, molecules or any other particles present in a given system are expressed in the terms of **Avogadro constant** (6.022×10^{23}). This is known as **1 mol** of the respective particles or entities.
- Chemical reactions represent the chemical changes undergone by different elements and compounds. The coefficients indicate the molar ratios and the respective number of particles taking part in a particular reaction. The quantitative study of the reactants required or the products formed is called **stoichiometry**. Using stoichiometric calculations, the amount of one or more reactant(s) required to produce a particular amount of product can be determined and vice-versa.
- The amount of substance present in a given volume of a solution is expressed in number of ways, e.g., mass per cent, mole fraction, molarity and molality
- Equivalent mass is the number of parts by weight of the substance that combines or displaces, directly or indirectly, 1.008 parts by mass of hydrogen or 8 parts by mass of oxygen or 35.5 parts by mass of chlorine. It can be calculated as:

$$\text{Equivalent mass, } E = \frac{\text{Molecular mass}}{Z(\text{valency factor})}$$

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

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 and 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 law of conservation of mass and energy.

Example - 4

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

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

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

$$= 0.600 \text{ m}$$

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 .

\therefore 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 .

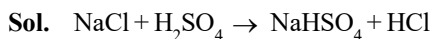
Example - 8

Why atomic masses are the average values ?

Sol. Most of the elements exist as 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 (i.e., 35.5).

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 ?



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

$$\begin{aligned}x + 9.8 &= 12.0 + 2.75 \\&= 14.75 \\x &= 4.95 \text{ g}\end{aligned}$$

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
 $= (2.4 - 1.68) = 0.72 \text{ g}$

Ratio 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 = $(2.9 - 2.03) = 0.87 \text{ g}$

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.

Oxide 1	Carbon	Oxygen
	42.9%	57.1%

\therefore Amount of oxygen that combines with 1 g carbon

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

Oxide 1	Carbon	Oxygen
	27.3%	72.7%

\therefore Amount of oxygen that combines with 1 g carbon

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

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 :

- Number of moles of carbon atoms
- Number of moles of hydrogen atoms
- Number of molecules of ethane

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

\therefore 3 moles of C_2H_6 will C-atoms = 6 moles

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

\therefore 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.,

$$6.02 \times 10^{23} \text{ molecules}$$

\therefore 3 moles of C_2H_6 will contain ethane molecules

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

$$= 18.06 \times 10^{23} \text{ molecules}$$

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
 $= 22.6 \text{ g zinc}$

1 g of zinc sulphate crystals will be obtained from
 $= 22.6/100 \text{ g zinc}$

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

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

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

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

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

Example - 15

Calculate the molecular mass of :

(i) H_2O (ii) CO_2 (iii) CH_4

Sol. (i) Molecular mass of H_2O = $2 (1.008 \text{ amu}) + 16.00 \text{ amu}$
 $= 18.016 \text{ amu}$

(ii) Molecular mass of CO_2 = $12.01 \text{ amu} + 2 \times 16.00 \text{ amu}$
 $= 44.01 \text{ amu}$

(iii) Molecular mass of CH_4 = $12.01 \text{ amu} + 4 (1.008 \text{ amu})$
 $= 16.042 \text{ amu}$

Example - 16

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

Sol. Mass % of an element

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

$$\text{Now, molar mass of } \text{Na}_2\text{SO}_4 = 2 (23.0) + 32.0 + 4 \times 16.0$$

$$= 142 \text{ g mol}^{-1}$$

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

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

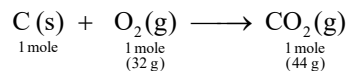
$$\text{Mass per cent of oxygen} = \frac{64}{142} \times 100 = 45.07\%$$

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

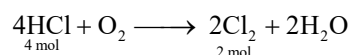


- (i) In air, combustion is complete. Therefore, CO_2 produced from the combustion of 1 mole of carbon = 44 g.
- (ii) As only 16 g of dioxygen is available, it can combine only with 0.5 mole of carbon, i.e., dioxygen is the limiting reactant. Hence, CO_2 produced = 22 g.
- (iii) Here again, dioxygen 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 :



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

\therefore 4 moles HCl give 2 moles Cl_2

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

$$\text{Volume of } \text{Cl}_2 \text{ at STP} = 22.4 \times 0.5 = 11.2 \text{ litre}$$

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 $82.0245 \text{ g mol}^{-1}$.

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

∴ 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

∴ Mass of sodium acetate acquired

$$= \frac{0.375}{2} \text{ mole} \times 82.0245 \text{ g mol}^{-1} \\ = 15.380 \text{ g.}$$

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 =

$$\frac{(10 \times 19.6) + (11 \times 80.4)}{100} = 10.804 \text{ amu}$$

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.

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

$$\text{or } 12x + 1300 - 13x = 1201.1 \\ x = 98.9$$

Abundance of carbon-12 is 98.9%

Example - 23

Calculate the mass of 2.5 gram atoms of oxygen.

Sol. We know that

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

$$\text{So, Mass of oxygen} = 2.5 \times 16 = 40.0 \text{ g}$$

Example - 24

Calculate the gram atoms in 2.3 g of sodium.

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

[Atomic mass of sodium = 23 g]

Example - 25

Calculate the mass of 1.5 gram molecule of sulphuric acid.

Sol. Molecular mass of H₂SO₄

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

Gram-molecular mass of H₂SO₄ = 98.0 g

$$\text{Mass of 1.5 gram molecule of H}_2\text{SO}_4 = 98.0 \times 1.5 = 147.0 \text{ g}$$

Example - 26

Calculate the actual mass of one molecule of carbon dioxide (CO₂).

Sol. Molecular mass of CO₂ = 44 amu

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

$$\text{So, the actual mass of CO}_2 = 44 \times 1.66 \times 10^{-24} \\ = 7.304 \times 10^{-23} \text{ g}$$

Example - 27

Calculate the mass of a single atom of sulphur.

Sol. Gram-atomic mass of sulphur = 32 g

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

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

Example - 28

What is the concentration of sugar (C₁₂H₂₂O₁₁) 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 (C₁₂H₂₂O₁₁) = 12 × 12 + 22 × 1 + 11 × 16 = 342 g mol⁻¹

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

$$\text{Volume of solution} = 2 \text{ L} \quad (\text{Given})$$

$$\text{Molar concentration} = \frac{\text{Moles of solute}}{\text{Volume of sol in L}} = \frac{0.0582 \text{ mol}}{2 \text{ L}} \\ = 0.0291 \text{ mol L}^{-1} = 0.0291 \text{ M}$$

Example - 29

How many water molecules 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 :

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

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

Solution :

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

$$\begin{aligned} \text{Number of molecules of water} &= 0.05 \times 6.02 \times 10^{23} \\ &= 3.01 \times 10^{22} \end{aligned}$$

As one molecule of water contains one oxygen atom,

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

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

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 = 6.02×10^{23}

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

$$\text{So, } \frac{3.01 \times 10^{22}}{6.02 \times 10^{23}} = \frac{x}{17}$$

$$\text{or } x = \frac{17 \times 3.01 \times 10^{22}}{6.02 \times 10^{23}} = 0.85 \text{ g}$$

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

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

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

1 molecule of oxygen contains

$$= 2 \text{ atoms of oxygen}$$

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

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

$$= 3.01 \times 10^{23} \text{ atoms}$$

Example - 32

How many electrons are present in 1.6 g of methane ?

Sol. Gram-molecular mass of methane

$$(\text{CH}_4) = 12 + 4 = 16 \text{ g}$$

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

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

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

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

Example - 33

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

Sol. Formula mass of calcium carbonate

$$(\text{CaCO}_3) = 100$$

$$\text{No. of moles of } \text{CaCO}_3 = \frac{\text{Mass in grams}}{\text{Formula mass}} = \frac{25}{100}$$

$$= 0.25 \text{ mole}$$

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

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

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

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

$$\begin{aligned} &= \text{Mass of one atom} \times 6.02 \times 10^{23} \\ &= 6.644 \times 10^{-23} \times 6.02 \times 10^{23} \\ &= 40 \text{ g} \end{aligned}$$

$$40 \text{ kg} = 40,000 \text{ g}$$

$$\begin{aligned} \text{Number of grams atoms} &= \frac{\text{Mass of the element in grams}}{\text{Atomic mass in grams}} \\ &= \frac{40000}{40} = 1000 \end{aligned}$$

Example - 35

250 cm³ of sulphuric acid solution contain 24.5 g of H₂SO₄. If the density of the solution is 1.98 g cm⁻³, determine (i) molarity and (ii) molality.

Sol. (i) Molecular mass of H₂SO₄ = 2 + 32 + 64 = 98

$$\text{No. of moles of H}_2\text{SO}_4 \text{ in solution} = \frac{24.5}{98} = 0.25$$

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

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

(ii) Mass of solution = 250 × 1.98 = 495.0 g

$$\begin{aligned} \text{Mass of solvent} &= \text{Mass of solution} - \text{Mass of solute} \\ &= 495.0 - 24.5 = 470.5 \text{ g} = 0.4705 \text{ kg} \end{aligned}$$

$$\text{Molality} = \frac{0.25}{0.4705} = 0.53 \text{ m}$$

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.

$$\text{Molar mass of nitric acid (HNO}_3\text{)} = 1 + 14 + 48 = 63 \text{ g mol}^{-1}$$

$$\therefore \text{Moles of } 69 \text{ g HNO}_3 = \frac{69 \text{ g}}{63 \text{ g mol}^{-1}} = 1.095 \text{ mole}$$

$$\begin{aligned} \text{Volume of 100 g nitric acid solution} &= \frac{100 \text{ g}}{1.41 \text{ g mL}^{-1}} \\ &= 70.92 \text{ mL} = 0.07092 \text{ L} \end{aligned}$$

$$\begin{aligned} \therefore \text{Conc. of HNO}_3 \text{ in moles per litre} &= \frac{1.095 \text{ mole}}{0.07092 \text{ L}} \\ &= 15.44 \text{ M} \end{aligned}$$

Example - 37

How much copper can be obtained from 100 g of copper sulphate (CuSO₄) ? (Atomic mass of Cu = 63.5 amu)

Sol. 1 mole of CuSO₄ contains 1 mole (1 g atom) of Cu

$$\text{Molar mass of CuSO}_4 = 63.5 + 32 + 4 \times 16 = 159.5 \text{ g mol}^{-1}$$

$$\begin{aligned} \text{Thus, Cu that can be obtained from 159.5 g of CuSO}_4 \\ &= 63.5 \text{ g} \end{aligned}$$

$$\begin{aligned} \therefore \text{Cu that can be obtained from 100 g of CuSO}_4 \\ &= \frac{63.5}{159.5} \times 100 \text{ g} \\ &= 39.81 \text{ g} \end{aligned}$$

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 (CH₃OH) = 32 g mol⁻¹

$$= 0.032 \text{ kg mol}^{-1}$$

$$\begin{aligned} \text{Molarity of the given solution} &= \frac{0.793 \text{ kg L}^{-1}}{0.032 \text{ kg mol}^{-1}} \\ &= 24.78 \text{ mol L}^{-1} \end{aligned}$$

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

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

Example - 39

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

$$1 \text{ Pa} = 1 \text{ N m}^{-2}$$

If mass of air at sea level is 1034 g cm⁻², calculate the pressure in pascal.

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

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

$$\begin{aligned} & \frac{1034\text{g} \times 9.8 \text{ ms}^{-2}}{\text{cm}^2} \times \frac{1\text{kg}}{1000\text{g}} \times \frac{100 \text{ cm}}{1\text{m}} \times \frac{100\text{cm}}{1\text{m}} \\ & \times \frac{1\text{N}}{1\text{kg ms}^{-2}} \times \frac{1\text{Pa}}{1\text{N m}^{-2}} \\ & = 1.01332 \times 10^5 \text{ Pa} \end{aligned}$$

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]

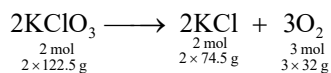
Sol.	Element	Percentage	Atomic mass
	Potassium	26.6	39.1
	Chromium	35.4	52.0
	Oxygen	38.1	16.0
	Relative no. of atoms	Simplest ratio	Simplest whole no. ratio
	$\frac{26.6}{39.1} = 0.68$	$\frac{0.68}{0.68} = 1$	$1 \times 2 = 2$
	$\frac{35.4}{52} = 0.68$	$\frac{0.68}{0.68} = 1$	$1 \times 2 = 2$
	$\frac{38.1}{16} = 2.38$	$\frac{2.38}{0.68} = 3.5$	$3.5 \times 2 = 7$

Therefore, empirical formula is $\text{K}_2\text{Cr}_2\text{O}_7$.

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 :



$$\therefore 3 \times 32 \text{ g O}_2 \text{ is produced by } 2 \times 122.5 \text{ g KClO}_3$$

$$\therefore 1.23 \text{ g O}_2 \text{ will be produced by } \frac{245}{96} \times 1.23 = 3.139 \text{ g}$$

$$(b) \therefore 2 \times 122.5 \text{ g KClO}_3 \text{ give } 2 \times 74.5 \text{ g KCl}$$

$$\therefore 3.139 \text{ g KClO}_3 \text{ will give } \frac{2 \times 74.5 \times 3.139}{2 \times 122.5} = 1.909 \text{ g}$$

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 contains of $(800 \times 6.022 \times 10^{23})/40$ Ca atoms
= 1.2044×10^{25} Ca atoms Ans.

Example - 43

Calculate the mass of carbon in 1kg of sugar ($\text{C}_{12}\text{H}_{22}\text{O}_{11}$)

Sol. Molecular mass of sugar = $12 \times 12 + 22 \times 1 + 11 \times 16$
= 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?



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 the LR and H_2 is the ER.

Since, 28g N_2 reacts with = 6g H_2 ;

1000g N_2 reacts = with $1000 \times 6/28 = 214.3\text{g H}_2$

So, H_2 is the ER and the amount of H_2 in excess
 $= 1000 - 214.3 = 785.7 \text{ g Ans.}$

Also, $28 \text{ g } N_2$ produces $= 34 \text{ g } NH_3$;

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

$= 1.214 \text{ kg } NH_3 \text{ Ans.}$

Example - 45

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

Sol. H_2SO_4 taken $= 98\% \Rightarrow 100 \text{ g}$ of solution contains $98 \text{ g } H_2SO_4$.

mass of solution $= 100 \text{ g}$

mass of solute, $H_2SO_4 = 98 \text{ g}$

mass of solvent $= 100 - 98 = 2 \text{ g} = 0.002 \text{ kg}$

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

$= 12.5 \text{ M}$

molality, $m = \frac{\text{moles of solute}}{\text{mass of solvent (kg)}} = \frac{1}{0.002}$

$= 500 \text{ m}$

Example - 46

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

Sol. Moles of $NaOH$ in 1^{st} solution $= MV = 3 \times 3 = 9$.

Moles of $NaOH$ in 2^{nd} solution $= 3 \times 5 = 15$.

Thus on mixing the total moles of $NaOH = 24$.

Final Molarity $= 1 \text{ M}$

Final moles $= 24$

Total Volume of solutions $= 8 \text{ L}$.

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

The mixture needs to be diluted 3 folds

Example - 47

An organic compound 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: $\frac{\text{Molecular Formula Mass}}{\text{Empirical Formula Mass}} = 3 = n\text{-factor}$

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) $490 \text{ g } H_2SO_4$ (b) $1600 \text{ g } NaOH$

(c) $730 \text{ g } HCl$ (d) $0.37 \text{ g } Ca(OH)_2$

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 $H_2SO_4 = 490/49 = 10$

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

(c) No. of eq. of $HCl = 730/36.5 = 20 \text{ Ans.}$

(d) No. of eq. of $Ca(OH)_2 = 0.37/37 = 0.01$
 $= 10 \text{ milli-eq. Ans}$

Example - 49

A mixture of three acids 3.65 g of HCl, 4.9 g H₂SO₄ and 9 g H₂C₂O₄ 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.'

$$\begin{aligned}\Sigma (w/E)_{\text{ACIDS}} &= \Sigma (w/E)_{\text{BASES}} \\ 3.65/36.5 + 4.9/49 + 9/45 &= x/40 + 7.4/37 \\ \Rightarrow x &= 8\text{g}\end{aligned}$$

Example - 50

Calculate the Equivalent mass of Al₂(SO₄)₃ ?

Sol. 1 equivalent of Al₂(SO₄)₃ = 1 equivalent of Al³⁺ + 1 equivalent of SO₄²⁻

$$E(\text{Al}_2(\text{SO}_4)_3) = E(\text{Al}^{3+}) + E(\text{SO}_4^{2-})$$

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

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 Na₂CO₃ 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 H₂SO₄ that will be completely neutralized by 125g of Na₂CO₃ solution.

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

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

Since Na₂CO₃ is completely neutralized by HCl

$$\therefore \text{Meq. of Na}_2\text{CO}_3 = \text{Meq. of HCl}$$

$$N \times 25 = 32.9 \times 3$$

$$\therefore N_{\text{Na}_2\text{CO}_3} = 3.948$$

Now Na₂CO₃ fresh solution reacts with H₂SO₄

$$\text{Wt. of Na}_2\text{CO}_3 \text{ solution} = 125\text{ g}$$

$$\therefore \text{Volume of Na}_2\text{CO}_3 \text{ solution} = \frac{125}{1.25} = 100\text{ mL}$$

$$\therefore \text{Meq. of H}_2\text{SO}_4 = \text{Meq. of Na}_2\text{CO}_3$$

$$0.84 \times V = 100 \times 3.948$$

$$\therefore \text{Volume of H}_2\text{SO}_4 \text{ required} = 470\text{ mL}$$

Example - 52

5 mL of 8N HNO₃, 4.8 mL of 5N HCl and a certain volume of 17M H₂SO₄ are mixed together and made upto 2 litre 30 mL of this acid mixture exactly neutralizes 42.9 mL of Na₂CO₃ solution containing 1g of Na₂CO₃. 10H₂O in 100 mL of water. Calculate the amount of sulphate ions in g present in solution.

Sol. Meq. of HNO₃ = 5 × 8 = 40

$$\text{Meq. of HCl} = 4.8 \times 5 = 24$$

$$\text{Meq. of H}_2\text{SO}_4 = V \times 17 \times 2 = 34V \text{ (Let } V \text{ mL of H}_2\text{SO}_4\text{)}$$

$$\therefore \text{Total Meq. of acid in 2 litre solution} = 40 + 24 + 34V = 64 + 34V$$

Now Meq. of acid in 30 mL solution = Meq. of Na₂CO₃ used for it

$$\text{Meq. of Na}_2\text{CO}_3$$

$$= 42.9 \times \frac{1 \times 1000}{286/2 \times 100} = 3 \left(N_{\text{Na}_2\text{CO}_3} = \frac{1}{286/2} \times \frac{1000}{100} \right)$$

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

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

$$\text{Now Meq. of H}_2\text{SO}_4 = \text{Meq. of SO}_4^{2-} = 34V = 136$$

$$\therefore \text{Meq. of SO}_4^{2-} = 136 \quad \therefore \frac{w}{96/2} \times 1000 = 136$$

$$\therefore \text{Weight of SO}_4^{2-} = 6.528\text{g}$$

Example - 53

Calculate the molarity, molality and mole fraction of ethyl alcohol in a solution of total volume 95 mL prepared by adding 50 mL of ethyl alcohol (density = 0.789 mL⁻¹) to 50 mL water (density = 1.00 g mL⁻¹)

Sol. No. of moles of ethyl alcohol = $\frac{\text{Vol.} \times \text{density}}{\text{Mol. mass}}$

$$= \frac{50 \times 0.789}{46} = 0.8576$$

$$\text{No. of moles of water} = \frac{\text{Vol.} \times \text{density}}{\text{Mol. mass}} = \frac{50 \times 1}{18} = 2.7777$$

$$\text{Molarity} = \frac{\text{No. of moles}}{\text{Vol. of sol. in mL}} \times 1000$$

$$= \frac{0.8576}{95} \times 1000 = 9.027\text{M}$$

$$\text{Molality} = \frac{\text{No. of mole of solute}}{\text{Mass of solvent in gram}} \times 1000$$

$$= \frac{0.8576}{50} \times 1000 = 17.152\text{m}$$

$$\text{Mole fraction} = \frac{0.8576}{0.8576 + 2.7777} = \frac{0.8576}{3.6353} = 0.236$$

Example - 54

A solution will be contains 410.3 g of H_2SO_4 per litre of solution at 20°C . If the density is 1.243 g/mL, what will be its molarity and molality?

Sol. Mol. mass of $\text{H}_2\text{SO}_4 = 98$

$$\text{No. of moles of } \text{H}_2\text{SO}_4 = \frac{410.3}{98} = 4.186$$

$$\begin{aligned} \text{Molarity of } \text{H}_2\text{SO}_4 \text{ solution} &= \frac{\text{No. of moles of } \text{H}_2\text{SO}_4}{\text{Volume of soln. in litre}} \\ &= \frac{4.186}{1} = 4.186\text{M} \end{aligned}$$

$$\text{Mass of 1 litre } \text{H}_2\text{SO}_4 \text{ solution} = 1000 \times 1.243 = 1243 \text{ g}$$

$$\text{Mass of water} = (1243 - 410.3) = 832.7 \text{ g} = \frac{832.7}{1000} \text{ kg}$$

Molality of solution =

$$\frac{\text{No. of moles of } \text{H}_2\text{SO}_4}{\text{Mass of water in kg}} = \frac{4.186}{832.7} \times 1000 = 5.027\text{m}$$

Example - 55

Calculate the mole fraction of benzene in solution containing 30% by mass in CCl_4 ?

Sol. Let the mass of solution be 100 gm

Mass of Benzene = 30 gm

Mass of $\text{CCl}_4 = 70 \text{ gm}$

$$\text{Moles of Benzene} = \frac{30}{78} = 0.385$$

$$\text{Moles of } \text{CCl}_4 = \frac{70}{154} = 0.45 \text{ moles}$$

$$\text{Mole fraction (Benzene)} = \frac{0.385}{0.385 + 0.45} = 0.461$$

EXERCISE - 1 : BASIC OBJECTIVE QUESTIONS

Laws of Chemical Combination

- One of the following combinations illustrate law of reciprocal proportions
(a) $\text{N}_2\text{O}_3, \text{N}_2\text{O}_4, \text{N}_2\text{O}_5$ (b) $\text{NaCl}, \text{NaBr}, \text{NaI}$
(c) $\text{CS}_2, \text{CO}_2, \text{SO}_2$ (d) $\text{PH}_3, \text{P}_2\text{O}_3, \text{P}_2\text{O}_5$
- 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
- 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
- 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
- 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
- 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.
- 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 :
$$\text{X} + \text{Y} = \text{R} + \text{S}$$

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) $p = q$
- 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 is no change in mass.
- 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
- A sample of CaCO_3 has $\text{Ca} = 40\%$, $\text{C} = 12\%$ and $\text{O} = 48\%$. 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
- 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

12. 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

Mole Concept

13. The number of water molecules present in a drop of water (volume = 0.0018 ml) at room temperature is (density of $H_2O = 1 \text{ g/mL}$)

(a) 6.023×10^{19} (b) 1.084×10^{18}
(c) 4.84×10^{17} (d) 6.023×10^{23}

14. 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

15. 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

16. 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)

17. 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}

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

(a) $1.4 \times 10^{-21} \text{ g}$ (b) $1.09 \times 10^{-21} \text{ g}$
(c) $5.025 \times 10^{23} \text{ g}$ (d) $16.023 \times 10^{23} \text{ g}$

19. 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

20. 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

21. 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

22. 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.

23. 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

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

(a) 6.02×10^{23} (b) $2 \times 6.02 \times 10^{23}$
(c) $3 \times 6.02 \times 10^{23}$ (d) $4 \times 6.02 \times 10^{23}$

25. 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

26. 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

27. 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

28. 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

29. 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) $3.2 N_A$

30. 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) $\text{II} < \text{I} < \text{III} < \text{IV}$ (b) $\text{IV} < \text{III} < \text{II} < \text{I}$
 (c) $\text{II} > \text{I} > \text{III} > \text{IV}$ (d) $\text{I} < \text{II} < \text{IV} < \text{III}$
31. 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
32. Number of molecules in 1 litre of oxygen at NTP is :
 (a) $\frac{6.02 \times 10^{23}}{32}$ (b) $\frac{6.02 \times 10^{23}}{22.4}$
 (c) 32×22.4 (d) $\frac{32}{22.4}$
36. 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
37. 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) $\text{C}_7\text{H}_5\text{NO}_2$ (b) $\text{C}_7\text{H}_5\text{N}_2\text{O}$
 (c) $\text{C}_7\text{H}_9\text{NO}$ (d) $\text{C}_7\text{H}_5\text{NO}$
38. Formula which represents a simple ratio of atoms different elements present in a molecule of the substance is called :
 (a) Molecular formula (b) Empirical formula
 (c) Structural formula (d) None of these.
39. 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
40. Insulin contains 3.4% sulphur. What will be the minimum molecular weight of insulin?
 (a) 94.117 (b) 1884
 (c) 941.176 (d) 976

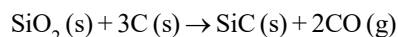
Percentage Composition,

Empirical and Molecular Formulae

33. 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
34. If 20% nitrogen is present in a compound, its minimum molecular weight can be
 (a) 144 (b) 28
 (c) 100 (d) 70
35. 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
41. If 0.5 mol of BaCl_2 is mixed with 0.2 mol of Na_3PO_4 , the maximum number of mole of $\text{Ba}_3(\text{PO}_4)_2$ that can be formed is
 (a) 0.7 (b) 0.5
 (c) 0.30 (d) 0.10
42. 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
43. 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

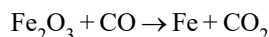
Chemical Equations and Stoichiometry

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



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
45. Iron (III) oxide can be reduced with CO to form metallic iron as described by unbalanced chemical reaction

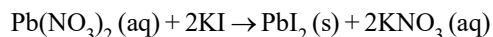


The number of moles of CO required to form one mole of Fe from its oxide is

- (a) 1 (b) 1.5
(c) 2 (d) 3
46. 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

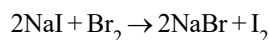
47. Given the reaction



What is the mass of PbI_2 that will precipitate if 10.2 g of $\text{Pb}(\text{NO}_3)_2$ 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

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 ?



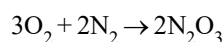
- (a) 3.30 (b) 4.80
(c) 6.59 (d) 9.75

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

- (a) $\text{Na}_2\text{SO}_3 \cdot 4\text{H}_2\text{O}$ (b) $\text{Na}_2\text{SO}_3 \cdot 6\text{H}_2\text{O}$
(c) $\text{Na}_2\text{SO}_3 \cdot \text{H}_2\text{O}$ (d) $\text{Na}_2\text{SO}_3 \cdot 2\text{H}_2\text{O}$

Limiting Reagent and Excess Reactant

50. 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 :



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

51. 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

52. 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 precipitated will be

- (a) 0.005 mol (b) 0.00025 mol
(c) 0.025 mol (d) 0.0025 mol

53. Equal weights of zinc and iodine react together and the iodine is completely converted to ZnI_2 . What fraction by weight of the original zinc remains unreacted? ($\text{Zn} = 65$, $\text{I} = 127\text{g/mol}$)

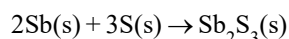
- (a) 0.6 (b) 0.74
(c) 0.47 (d) 0.17

Percent Yield and Purity, POAC

54. 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

55. Antimony reacts with sulphur according to the equation



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

What is the percentage 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 %

56. NH_3 is produced according to the following reaction :
- $$\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightarrow 2\text{NH}_3(\text{g})$$
- 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%
57. A 1.50 g sample of an ore containing silver was dissolved, 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%
58. NaOH is formed according to the reaction
- $$2\text{Na} + \frac{1}{2}\text{O}_2 \rightarrow \text{Na}_2\text{O}$$
- $$\text{Na}_2\text{O} + \text{H}_2\text{O} \rightarrow 2\text{NaOH}$$
- To make 4g of NaOH , Na required is
- (a) 4.6g (b) 4.0g
(c) 2.3g (d) 0.23g
59. 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
60. 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
63. 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
64. What volume of 0.4 M $\text{FeCl}_3 \cdot 6\text{H}_2\text{O}$ will contain 600 mg of Fe^{3+} ?
- (a) 49.85 mL (b) 26.78 mL
(c) 147.55 mL (d) 87.65 mL
65. 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
66. An antifreeze mixture contains 40% ethylene glycol ($\text{C}_2\text{H}_6\text{O}_2$) 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
67. 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
68. In which mode of expression, the concentration of a solution remains independent of temperature ?
- (a) Molarity (b) Normality
(c) Formality (d) Molality
69. 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.
70. Molarity and Normality change with temperature because they involve :
- (a) Moles (b) equivalents
(c) weights (d) volumes
71. 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

Reactions in Aqueous Media and Strength of Solution

61. Mole fraction of ethanol in ethanol - water mixture is 0.25. Hence, percentage concentration of ethanol ($\text{C}_2\text{H}_6\text{O}$) by weight of mixture is
- (a) 25 (b) 75
(c) 46 (d) 54
62. 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

72. 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
73. Normality of a 2 M sulphuric acid is
 (a) 2 N (b) 4 N
 (c) N / 2 (d) N / 4
74. 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
75. 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
76. 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
77. What is the weight % sulphuric acid in an aqueous solution which is 0.502 M in sulphuric acid ? The specific gravity of the solution is 1.07
 (a) 4.77 % (b) 5.67 %
 (c) 9.53 % (d) 22.0 %
78. What is the molarity of SO_4^{2-} ion in aqueous solution that contain 34.2 ppm of $\text{Al}_2(\text{SO}_4)_3$? (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
79. 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
80. 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
81. 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

Applications of Strength of Solutions

82. 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
83. 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
84. 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
85. 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).
86. 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
87. 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

Equivalent Concept and Equivalent Weight

88. The Equivalent weight 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
89. The Equivalent weight of H_3PO_4 in the reaction is

$$\text{Ca(OH)}_2 + \text{H}_3\text{PO}_4 \rightarrow \text{CaHPO}_4 + 2\text{H}_2\text{O}$$
 (Ca = 40, P = 31, O = 16)
 (a) 49 (b) 98
 (c) 32.66 (d) 147

90. 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
91. 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
92. 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 Equivalent weight of the metal is
 (a) 12 (b) 24
 (c) 18 (d) 15
93. 1.0 g of a monobasic acid when completely reacted with 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
94. How many grams of phosphoric acid would be needed to neutralise 100 g of magnesium hydroxide ? (The molecular weights are : $\text{H}_3\text{PO}_4 = 98$ and $\text{Mg}(\text{OH})_2 = 58.3$)
 (a) 66.7 g (b) 252 g
 (c) 112 g (d) 168 g
95. 0.116 g of $\text{C}_4\text{H}_4\text{O}_4$ (A) is neutralised by 0.074 g of $\text{Ca}(\text{OH})_2$. Hence, protonic hydrogen (H^\oplus) in (A) will be
 (a) 1 (b) 2
 (c) 3 (d) 4

EXERCISE - 2 : PREVIOUS YEAR JEE MAINS QUESTIONS

- Number of atoms in 558.5 Fe (at. wt. 55.85) is (2002)
 - Twice that in 60 g carbon
 - 6.023×10^{22}
 - Half in 8 g He
 - $558.5 \times 6.023 \times 10^{23}$
- 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)
 - C₆H₈N₂
 - C₇H₁₀N
 - C₅H₆N₃
 - C₄H₁₈N₃
- Number of atoms in 560g of Fe (atomic mass 56 g mol⁻¹) is (2002)
 - twice that of 70 g N
 - half that of 20 g H
 - Both (a) and (b)
 - None of the above
- What volume of H₂ 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 H₂ (2003)
 - 89.6 L
 - 67.2 L
 - 44.8 L
 - 22.4 L
- 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)
 - 0.07
 - 0.14
 - 0.28
 - 0.35
- To neutralize completely 20 mL of 0.1 M aqueous solution of phosphorus (H₃PO₃) acid, the volume of 0.1 M aqueous KOH solution required is (2004)
 - 60 mL
 - 20 mL
 - 40 mL
 - 10 mL
- 6.023×10^{20} molecules of urea are present in 100 mL of its solution. The concentration of urea solution is (2004)
 - 0.001 M
 - 0.1 M
 - 0.02 M
 - 0.01 M
- Density of a 2.05 M solution of acetic acid in water is 1.02 g/mL. The molality of the solution is (2006)
 - 0.44 mol Kg⁻¹
 - 1.14 mol kg⁻¹
 - 3.28 mol kg⁻¹
 - 2.28 mol kg⁻¹
- How many moles of magnesium phosphate, Mg₃(PO₄)₂ will contain 0.25 mole of oxygen atoms ? (2006)
 - 0.02
 - 3.125×10^{-2}
 - 1.25×10^{-2}
 - 2.5×10^{-2}
- The density (in g mL⁻¹) of a 3.60 M sulphuric acid solution that is 29% H₂SO₄ (Molar mass = 98g mol⁻¹) by mass will be (2007)
 - 1.64
 - 1.88
 - 1.22
 - 1.45
- The mass of potassium dichromate crystals required to oxidise 750 cm³ of 0.6 M Mohr's salt solution is (Given molar mass = 392) (2011)
 - 0.49 g
 - 0.45 g
 - 29.4 g
 - 2.2 g
- 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)
 - 0.50 M
 - 1.78 M
 - 1.02 M
 - 2.05 M
- 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)
 - 0.875 M
 - 1.00 M
 - 1.75 M
 - 0.0975 M
- 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)
 - 7 : 32
 - 1 : 8
 - 3 : 16
 - 1 : 4
- 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/Shift-1)
 - 1.00 M
 - 2.00 M
 - 2.50 M
 - 4.00 M
- The amount of oxygen in 3.6 mol of water is: (Online 2014/Shift-1)
 - 115.2 g
 - 57.6 g
 - 28.8 g
 - 18.4 g

17. A gaseous compound of nitrogen and hydrogen contains 12.5% (by mass) of hydrogen. The density of the compound relative to hydrogen is 16. The molecular formula of the compound is: **(Online 2014/Shift-2)**
- (a) N_2H_4 (b) NH_3
(c) N_3H (d) NH_2
18. $A + 2B + 3C \rightleftharpoons AB_2C_3$
- 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/Shift-1)**
- (a) 50 amu (b) 60 amu
(c) 70 amu (d) 40 amu
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. 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/Shift-1)**
- (a) C_4H_6 (b) C_2H_6O
(c) C_2H_4O (d) C_3H_6O
21. 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/Shift-2)**
- (a) 200 mL (b) 400 mL
(c) 600 mL (d) 800 mL
22. 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/Shift-1)**
- (a) 0.2 M (b) 0.3 M
(c) 0.6 M (d) 1.8 M
23. What quantity (in mL) of a 45% acid solution of a monoprotic 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/Shift-2)**
- (a) 320 (b) 325
(c) 316 (d) 330
24. 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
25. 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) $C_3H_4O_2$
26. 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/Shift-1)**
- (a) 0.35 (b) 0.41
(c) 0.48 (d) 0.54
27. For the following reaction the mass of water produced from 445 g of $C_{57}H_{110}O_6$ is : **(2019-01-09/Shift-2)**
- $$2C_{57}H_{110}O_6(s) + 163 O_2(g) \rightarrow 114CO_2(g) + 110 H_2O(l)$$
- (a) 490 g (b) 445 g
(c) 495 g (d) 890 g
28. A mixture of 100 mmol of $Ca(OH)_2$ and 2g of sodium sulphate was dissolved in water and the volume was made up to 100 mL. The mass of calcium sulphate formed and the concentration of OH^- in resulting solution, respectively, are : (Molar mass of $Ca(OH)_2$, Na_2SO_4 and $CaSO_4$ are 74, 143 and 136 g mol^{-1} , respectively; K_{sp} of $Ca(OH)_2$ is 5.5×10^{-6}) **(2019-01-10/Shift-1)**
- (a) 1.9 g, 0.28 mol L^{-1} (b) 13.6 g, 0.28 mol L^{-1}
(c) 1.9 g, 0.14 mol L^{-1} (d) 13.6 g, 0.14 mol L^{-1}
29. The amount of sugar ($C_{12}H_{22}O_{11}$) required to prepare 2 L of its 0.1 M aqueous solution is : **(2019-01-10/Shift-2)**
- (a) 136.8 g (b) 17.1 g
(c) 68.4 g (d) 34.2 g

30. A 10 mg effervescent tablet containing sodium bicarbonate and oxalic acid releases 0.25 mL of CO_2 at $T = 298.15 \text{ K}$ and $P = 1 \text{ bar}$. If molar volume of CO_2 is 25.0 L under such condition, what is the percentage of sodium bicarbonate in each tablet? (2019-01-11/Shift-1)
- [Molar mass of $\text{NaHCO}_3 = 84 \text{ g mol}^{-1}$]
- (a) 0.84 (b) 33.6
(c) 16.8 (d) 8.4
31. 25 mL of the given HCl solution requires 30 mL of 0.1 M sodium carbonate solution. What is the volume of this HCl solution required to titrate 30 mL of 0.2 M aqueous NaOH solution? (2019-01-11/Shift-2)
- (a) 25 mL (b) 75 mL
(c) 50 mL (d) 12.5 mL
32. 50 mL of 0.25 M oxalic acid is needed to neutralize 25 mL of sodium hydroxide solution. The amount of NaOH in 50 mL of the given sodium hydroxide solution is : (2019-01-12/Shift-1)
- (a) 40 g (b) 10 g
(c) 20 g (d) None of these.
33. 8 g of NaOH is dissolved in 18 g of H_2O . Mole fraction of NaOH in solution and molality (in mol kg^{-1}) of the solution respectively are : (2019-01-12/Shift-2)
- (a) 0.2, 22.20 (b) 0.2, 11.11
(c) 0.167, 11.11 (d) 0.167, 22.20
34. The percentage composition of carbon by mole in methane is : (2019-04-08/Shift-2)
- (a) 75% (b) 80%
(c) 25% (d) 20%
35. The strength of 11.2 volume solution of H_2O_2 is : [Given that molar mass of $\text{H} = 1 \text{ g mol}^{-1}$ and $\text{O} = 16 \text{ g mol}^{-1}$] (2019-04-08/Shift-2)
- (a) 13.6% (b) 3.4%
(c) 34% (d) 1.7%
36. For reaction $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightarrow 2\text{NH}_3(\text{g})$; identify dihydrogen (H_2) as a limiting reagent in the following reaction mixtures. (2019-04-09/Shift-1)
- (a) 56g of N_2 + 10 g of H_2 (b) 35 g of N_2 + 8g of H_2
(c) 28 g of N_2 + 6g of H_2 (d) 14g of N_2 + 4g of H_2
37. 10 mL of 1 mM surfactant solution forms a monolayer covering 0.24 cm^2 on a polar substrate. If the polar head is approximated as a cube, what is its edge length? (2019-04-09/Shift-2)
- (a) 1.0 pm (b) 2.0 pm
(c) 0.1 nm (d) 2.0 nm
38. The minimum amount of $\text{O}_2(\text{g})$ consumed per gram of reactant is for the reaction : (Given atomic mass : $\text{Fe} = 56, \text{O} = 16, \text{Mg} = 24, \text{P} = 31, \text{C} = 12, \text{H} = 1$) (2019-04-10/Shift-2)
- (a) $4\text{Fe}(\text{s}) + 3\text{O}_2(\text{g}) \rightarrow 2\text{Fe}_2\text{O}_3(\text{s})$
(b) $\text{P}_4(\text{s}) + 5\text{O}_2(\text{g}) \rightarrow \text{P}_4\text{O}_{10}(\text{s})$
(c) $\text{C}_3\text{H}_8(\text{g}) + 5\text{O}_2(\text{g}) \rightarrow 3\text{CO}_2(\text{g}) + 4\text{H}_2\text{O}(\text{l})$
(d) $2\text{Mg}(\text{s}) + \text{O}_2(\text{g}) \rightarrow 2\text{MgO}(\text{s})$
39. 5 moles of AB_2 weigh $125 \times 10^{-3} \text{ kg}$ and 10 moles of A_2B_2 weigh $300 \times 10^{-3} \text{ kg}$. The molar mass of $\text{A}(\text{M}_\text{A})$ and molar mass of $\text{B}(\text{M}_\text{B})$ in kg mol^{-1} are : (2019-04-12/Shift-1)
- (a) $\text{M}_\text{A} = 10 \times 10^{-3}$ and $\text{M}_\text{B} = 5 \times 10^{-3}$
(b) $\text{M}_\text{A} = 50 \times 10^{-3}$ and $\text{M}_\text{B} = 25 \times 10^{-3}$
(c) $\text{M}_\text{A} = 25 \times 10^{-3}$ and $\text{M}_\text{B} = 50 \times 10^{-3}$
(d) $\text{M}_\text{A} = 5 \times 10^{-3}$ and $\text{M}_\text{B} = 10 \times 10^{-3}$
40. The mole fraction of solvent in aqueous solution of a solute is 0.8. The molality (in mol kg^{-1}) of the aqueous solution is (2019-04-12/Shift-1)
- (a) 13.88×10^{-2} (b) 13.88×10^{-1}
(c) 13.88 (d) 13.88×10^{-3}
41. The ammonia (NH_3) released on quantitative reaction of 0.6 g urea (NH_2CONH_2) with sodium hydroxide (NaOH) can be neutralized by : (2020-01-07/Shift-2)
- (a) 200 mL of 0.2 N HCl (b) 100 mL of 0.1 N HCl
(c) 200 mL of 0.4 N HCl (d) 100 mL of 0.2 N HCl
42. 5g of Zinc is treated separately with an excess of
I. dilute hydrochloric acid and
III. aqueous sodium hydroxide
The ratio of the volume of H_2 evolved in these two (2020-01-09/Shift-2)
- (a) 2 : 1 (b) 1 : 2
(c) 1 : 1 (d) 1 : 4

43. The average molar mass of chlorine is 35.5 g mol^{-1} . The ratio of ^{35}Cl to ^{37}Cl in naturally occurring chlorine is close to :
(2020-09-06/Shift-2)

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

44. The volume (in mL) of 0.125 M AgNO_3 required to quantitatively precipitate chloride ions in 0.3 g of $[\text{Co}(\text{NH}_3)_6]\text{Cl}_3$ is $M_{[\text{Co}(\text{NH}_3)_6]\text{Cl}_3} = 267.46 \text{ g/mol}$

$M_{\text{AgNO}_3} = 169.87 \text{ g/mol}$ (2020-01-08/Shift-1)

45. The mass percentage of nitrogen in histamine is

(2020-01-09/Shift-1)

46. The ratio of the mass percentages of 'C & H' and 'C & O' of a saturated acyclic organic compound 'X' are 4 : 1 and 3 : 4 respectively. Then, the moles of oxygen gas required for complete combustion of two moles of organic compound 'X' is

(2020-09-02/Shift-2)

47. The mole fraction of glucose ($\text{C}_6\text{H}_{12}\text{O}_6$) in an aqueous binary solution is 0.1. The mass percentage of water in it, to the nearest integer, is

(2020-09-03/Shift-1)

48. The mass of ammonia in grams produced when 2.8 kg of dinitrogen quantitatively reacts with 1 kg of dihydrogen is

(2020-09-04/Shift-1)

49. The minimum number of moles of O_2 required for complete combustion of 1 mole of propane and 2 moles of butane is

(2020-05-09/Shift-1)

50. The formula of a gaseous hydrocarbon which requires 6 times of its own volume of O_2 for complete oxidation and produces 4 times its own volume of CO_2 is C_xH_y . The value of y is

(2021-02-24/Shift-2)

51. The number of significant figures in 50000.020×10^{-3} is

(2021-02-26/Shift-1)

52. The NaNO_3 weighed out to make 50 mL of an aqueous solution containing 70.0 mg Na^+ per mL is g. (Rounded off to the nearest integer)

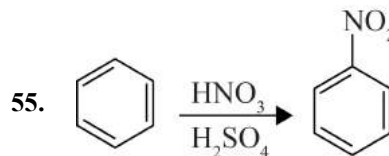
[Given: Atomic weight in g mol^{-1} - Na : 23 ; N : 14; O : 16]

(2021-02-26/Shift-2)

53. Complete combustion of 750 g of an organic compound provides 420 g of CO_2 and 210 g of H_2O . The percentage composition of carbon and hydrogen in organic compound is 15.3 and respectively. (Round off to the nearest integer).

(2021-03-16/Shift-1)

54. When 35 mL of 0.15 M lead nitrate solution is mixed with 20 mL of 0.12 M chromic sulphate solution, $\text{.....} \times 10^{-5}$ moles of lead sulphate precipitate out. (Round off to the nearest integer).
(2021-03-16/Shift-2)



In the above reaction, 3.9 g of benzene on nitration gives 4.92 g of nitrobenzene. The percentage yield of nitrobenzene in the above reaction is%. (Round off to the nearest integer)

(Given atomic mass: C : 12.0 u , H : 1.0 u , O : 16.0 u , N : 14.0 u)

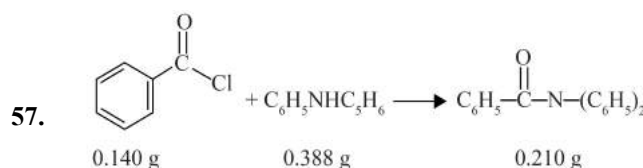
(2021-03-17/Shift-1)

56. The number of chlorine atoms in 20 mL of chlorine gas at STP is 10^{21} . (Round off to the nearest integer).

[Assume chlorine is an ideal gas at STP]

$R = 0.083 \text{ L bar mol}^{-1}\text{K}^{-1}$, $N_A = 6.023 \times 10^{23}$

(2021-03-17/Shift-2)



Consider the above reaction. The percentage yield of amide product is (Round off the nearest integer).

(Given: Atomic mass: C : 12.0 u , H : 1.0 u , N : 14.0 u , O : 16.0 u , Cl : 35.5 u)

(2021-03-17/Shift-2)

58. Complete combustion of 3 g of ethane gives $x \times 10^{22}$ molecules of water. The value of x is (Round off to the nearest integer).

[Use : $N_A = 6.023 \times 10^{23}$; Atomic masses in u : C : 12.0 ; O : 16.0 ; H : 1.0]

(2021-03-18/Shift-1)

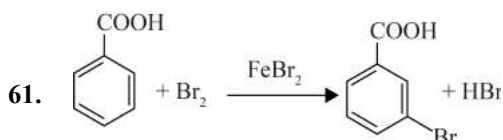
59. grams of 3-hydroxy propanal (MW = 74) must be dehydrated to produce 7.8 g of acrolein (MW = 56) ($\text{C}_3\text{H}_4\text{O}$) if the percentage yield is 64. (Round off to the nearest integer).

[Given: Atomic masses: C : 12.0 u , H : 1.0 u , O : 16.0 u]

(2021-03-18/Shift-1)

60. A reaction of 0.1 mole of Benzylamine with bromomethane gave 23 g of Benzyl trimethyl ammonium bromide. The number of moles of bromomethane consumed in this reaction are $n \times 10^{-1}$, when $n =$ _____. (Round off to the nearest integer).

[Given: Atomic masses: C : 12.0 u, H : 1.0 u, N : 14.0 u, Br : 80.0 u] (2021-03-18/Shift-1)



Consider the above reaction where 6.1 g of Benzoic acid is used to get 7.8 g of m-bromo benzoic acid is used to get 7.8g of m-bromo benzoic acid. The percentage yield of the product is _____. (Round off to the nearest integer).

[Given: Atomic masses: C : 12.0 u, H : 1.0 u, O : 16.0 u, Br : 80.0 u] (2021-03-18/Shift-2)

62. 250 mL of 0.5 M NaOH was added to 500 mL of 1 M HCl. The number of unreacted HCl molecules in the solution after complete reaction is _____ $\times 10^{21}$. (Nearest integer) ($N_A = 6.022 \times 10^{23}$) (2021-07-20/Shift-1)
63. 4g equimolar mixture of NaOH and Na_2CO_3 contains x g of NaOH and y g of Na_2CO_3 . The value of x is _____ g. (Nearest integer). (2021-07-20/Shift-2)
64. If the concentration of glucose ($\text{C}_6\text{H}_{12}\text{O}_6$) in blood is 0.72 g L^{-1} , the molarity of glucose in blood is _____ $\times 10^{-3}$ M. (Nearest integer) [Given: Atomic mass of C = 12, H = 1, O = 16 u] (2021-07-22/Shift-2)

65. Consider the complete combustion of butane, the amount of butane utilized to produce 72.0 g of water is _____ $\times 10^{-1}$ g. (in nearest integer). (2021-07-25/Shift-1)

66. The number of significant figures in 0.00340 is _____. (2021-07-25/Shift-2)

67. The density of NaOH solution is 1.2 g cm^{-3} . The molality of this solution is _____ m: (Round off to the nearest integer).

(Use: Atomic masses Na: 23.0 u, O: 16.0 u, H: 1.0 u, density of H_2O : 1.0 g cm^{-3}) (2021-07-27/Shift-1)

68. 100mL of Na_3PO_4 solution contains 3.45 g of sodium. The molarity of the solution is _____ $\times 10^{-2}$ mol L^{-1} . (Nearest integer)

[Atomic masses - Na: 23.0 u, O: 16.0 u, P: 31.0 u] (2021-08-26/Shift-2)

69. 100g of propane is completely reacted with 1000g of oxygen. The mole fraction of carbon dioxide in the resulting mixture is $x \times 10^{-2}$. The value of x is _____. (Nearest integer)?

[Atomic weight: H = 1.008; C = 12.00; O = 16.00] (2021-08-27/Shift-2)

70. The molarity of the solution prepared by dissolving 6.3 g of oxalic acid ($\text{H}_2\text{C}_2\text{O}_4 \cdot 2\text{H}_2\text{O}$) in 250 mL of water in mol L^{-1} is $x \times 10^{-2}$. The value of x is _____. (Nearest integer)

[Atomic mass H: 1.0, C: 12.0, O: 16.0] (2021-08-31/Shift-1)

71. The number of atoms in 8g of sodium is $x \times 10^{23}$. The value of x is _____. (Nearest integer)

[Given: $N_A = 6.02 \times 10^{23}$ mol $^{-1}$, Atomic mass of Na = 23.0 u] (2021-09-01/Shift-2)

72. If 80g of copper sulphate $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ is dissolved in deionized water to make 5 L of solution. The concentration of the copper sulphate solution is $x \times 10^{-3}$ mol L^{-1} . The value of x is _____. (nearest integer)

[Atomic masses Cu: 63.54 u, S: 32 u, O: 16 u, H: 1 u] (2021-09-01/Shift-2)

73. Complete combustion of 1.80 g of an oxygen containing compound ($\text{C}_x\text{H}_y\text{O}_z$) gave 2.64g of CO_2 and 1.08g of H_2O . The percentage of oxygen in the organic compound is

- (a) 51.63 (b) 63.53
(c) 50.33 (d) 53.33

74. Methylation of 10g of benzene gave 9.2g of toluene. Calculate the percentage yield of toluene _____. (Nearest integer) (2021-07-22/Shift-2)

75. Sodium oxide reacts with water to produce sodium hydroxide. 20.0 g of sodium oxide is dissolved in 500 mL of water. Neglecting the change in volume, the concentration of the resulting NaOH solution _____ $\times 10^{-1}$ M. (Nearest integer)

[Atomic mass: Na = 23.0, O = 16.0, H = 1.0] (2021-08-31/Shift-2)

EXERCISE - 3 : ADVANCED OBJECTIVE QUESTIONS

Objective Questions I (Only one correct option]

- 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
- A compound possesses 8% sulphur by mass. The least molecular mass is
(a) 200 (b) 400
(c) 155 (d) 355
- 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)
$$(\text{COOH})_2 \xrightarrow{\text{H}_2\text{SO}_4} \text{CO} + \text{CO}_2 + \text{H}_2\text{O}$$
$$2 \text{KOH} + \text{CO}_2 \longrightarrow \text{K}_2\text{CO}_3 + \text{H}_2\text{O}$$

(a) 28 g (b) 56 g
(c) 84 g (d) 112 g
- If 100 ml of H_2SO_4 (A) and 100 ml of H_2O (B) are mixed. Then the mass per cent of H_2SO_4 would be (Given density of $\text{H}_2\text{SO}_4 = 0.9 \text{ g/ml}$; density of $\text{H}_2\text{O} = 1.0 \text{ g/ml}$)
(a) 60 (b) 50
(c) 47.36 (d) 90
- 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
($d_{\text{H}_2\text{SO}_4} = 0.09 \text{ g mL}^{-1}$, $d_{\text{H}_2\text{O}} = 1.0 \text{ g mL}^{-1}$)
(a) 90 (b) 47.36
(c) 50 (d) 60
- $\text{BrO}_3^- + 5\text{Br}^- \longrightarrow \text{Br}_2 + 3\text{H}_2\text{O}$
If 50 ml of 0.1M BrO_3^- is mixed with 30 ml of 0.5 M Br^- solution that contains excess of H^+ 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}
- 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
- 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
- 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.
- 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
- 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
- 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
- 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}

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

(a) 18, 26 (b) 26, 18
(c) 13, 9 (d) None of these

15. 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.

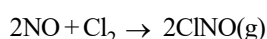
Column - I

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 reagent. |

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

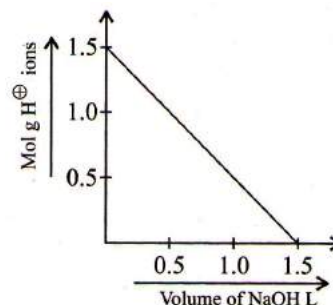
16. Consider the given reversible reaction at equilibrium



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

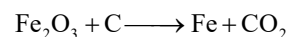
17. To 1 L of 1.0 M impure H_2SO_4 sample, 1.0 M NaOH solution was added and a plot was obtained as follows :



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%, $-1/2$

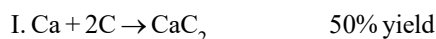
18. In the preparation of iron from haematite (Fe_2O_3) by the reaction with carbon



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

19. NH_3 is formed in the following steps :



To obtain 2 mol NH_3 , calcium required is :

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

20. 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 ml 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

21. Equal volumes of 0.200 M HCl and 0.400 M KOH are mixed. The concentrations of the ions in the resulting solution are :
- (a) $[K^+] = 0.40\text{M}$, $[Cl^-] = 0.20\text{M}$, $[H^+] = 0.20\text{M}$
 (b) $[K^+] = 0.20\text{M}$, $[Cl^-] = 0.10\text{M}$, $[OH^-] = 0.10\text{M}$
 (c) $[K^+] = 0.10\text{M}$, $[Cl^-] = 0.10\text{M}$, $[OH^-] = 0.10\text{M}$
 (d) $[K^+] = 0.20\text{M}$, $[Cl^-] = 0.10\text{M}$, $[OH^-] = 0.20\text{M}$
22. How much NaNO_3 must be weighed out to make 50 ml of an aqueous solution containing 70 mg of Na^+ per ml?
- (a) 12.394 g (b) 1.29 g
 (c) 10.934 g (d) 12.934 g
23. 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
24. 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
25. 1 g alloy of Cu and Zn reacted with excess of dil. H_2SO_4 to give H_2 gas which occupies 60 ml 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%
26. A solution of NaOH is prepared by dissolving 4.0 g of NaOH in 1 L of water. Calculate the volume of the HCl gas at STP that will neutralize 50 mL of this solution.
- (a) 224 mL (b) 56 mL
 (c) 112 mL (d) 448 mL
27. When a hydrate of Na_2CO_3 is heated until all the water is removed, it loses 54.3 per cent of its mass. The formula of the hydrate is
- (a) $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$ (b) $\text{Na}_2\text{CO}_3 \cdot 7\text{H}_2\text{O}$
 (c) $\text{Na}_2\text{CO}_3 \cdot 5\text{H}_2\text{O}$ (d) $\text{Na}_2\text{CO}_3 \cdot 3\text{H}_2\text{O}$
28. 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
29. 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) reciprocal proportions
30. How many moles of ferric alum $(\text{NH}_4)_2\text{SO}_4\text{Fe}_2(\text{SO}_4)_3 \cdot 24\text{H}_2\text{O}$ 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
31. 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
32. 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
33. 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
34. 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

Objection Question II

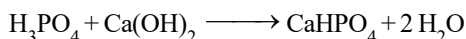
[One or more than one correct option]

35. Select dimensionless quantity(ies) :
- (a) vapour density (b) molality
(c) specific gravity (d) mass fraction
36. 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
37. 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
38. 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
39. 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
40. 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.
41. 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 in excess.
(c) 54.0g of Al is required.
(d) 159.0g of MnO is in excess.
42. 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 $NaNO_3$.
43. 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 OH^- remaining in solution is 0.8 M.
(b) The concentration of Cl^- remaining in solution is 1.2 M.
(c) The concentration of Ba^{2+} remaining in solution is 1.0 M
(d) 80 mmol of OH^- is in excess.
44. The density of a solution of H_2SO_4 is 1.84 gm/ml and it contains 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
45. 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
46. 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

47. 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_8 .

48. For the reaction


$$1 \text{ mol} \quad 1 \text{ mol}$$

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

49. Which of the following statements regarding the compound A_xB_y is/are correct ?

- 1 mole of A_xB_y contains 1 mole of A and 1 mole B
- 1 equivalent of A_xB_y contains 1 equivalent of A and 1 equivalent of B
- 1 mole of A_xB_y contains x moles of A and y moles of B
- equivalent weight of A_xB_y = equivalent weight of B

50. Which of the statements are true ?

- (a) The equivalent weight of $\text{Ca}_3(\text{PO}_4)_2$ is $\text{Mw}/6$.
- (b) The equivalent weight of $\text{Na}_3\text{PO}_4 \cdot 12\text{H}_2\text{O}$ is $\text{Mw}/3$.
- (c) The equivalent weight of K_2SO_4 is $\text{Mw}/2$.
- (d) The equivalent weight of potash alum $\text{K}_2\text{SO}_4 \cdot \text{Al}_2(\text{SO}_4)_3 \cdot 24\text{H}_2\text{O}$ is $\text{Mw}/8$.

51. 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 meq sample is 12%
(d) Mass of impurities present in the sample is 0.88 gm.

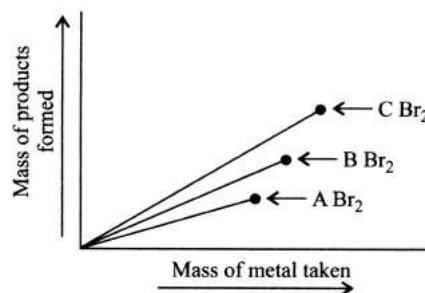
52. An aqueous solution of phosphoric acid (H_3PO_4) being titrated has molarity equal to 0.25 M. Which of the following could be normality of this solution ?

- (a) 0.25 N (b) 0.50 N
(c) 0.75 N (d) 1.00 N

53. An aqueous solution of 6.3g of a hydrated oxalic acid ($\text{H}_2\text{C}_2\text{O}_4 \cdot x\text{H}_2\text{O}$) 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 $\text{Ca}(\text{OH})_2$ solution for complete neutralization.

54. 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

Numeric Value Type Questions

55. 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.

56. 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 .

57. Igniting MnO_2 in air converts it quantitatively to Mn_3O_4 . A sample of pyrolusite is of the following composition : $\text{MnO}_2 = 80\%$, 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 ?
58. 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.
59. 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) $2\text{KClO}_3 \rightarrow 2\text{KCl} + 3\text{O}_2$ and the remaining undergoes change according to the equation :
- (b) $4\text{KClO}_3 \rightarrow 3\text{KClO}_4 + \text{KCl}$
- 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.
60. One commercial system removes SO_2 emission from smoke at 95°C by the following set of reaction :
- $$\text{SO}_2(\text{g}) + \text{Cl}_2(\text{g}) \longrightarrow \text{SO}_2\text{Cl}_2(\text{g})$$
- $$\text{SO}_2\text{Cl}_2(\text{g}) + \text{H}_2\text{O}(\text{l}) \longrightarrow \text{H}_2\text{SO}_4 + \text{HCl}$$
- $$\text{H}_2\text{SO}_4 + \text{Ca}(\text{OH})_2 \longrightarrow \text{CaSO}_4 + \text{H}_2\text{O}$$
- How many grams of CaSO_4 may be produced from 3.78g of SO_2 ?
61. 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 $\text{Al}_2(\text{CO}_3)_3$. Calculate the value of x.
62. 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.
63. 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)

Assertion Reason

- (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 Assertion is false but Reason is true.

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

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

- (a) A (b) B
(c) C (d) D

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

Reason (R) : Avogram is reciprocal of Avogadro's number.

- (a) A (b) B
(c) C (d) D

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

Reason (R) : 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

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

Reason (R) : The volume of solution is easier to measure than its mass.

- (a) A (b) B
(c) C (d) D

68. **Assertion (A)** : Molality of solution is independent of temperature while mole fraction depends on temperature.

Reason (R) : 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

69. **Assertion (A) :** 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 :

$$M_1 V_1 = M_2 V_2$$

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

- (a) A (b) B
(c) C (d) D

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

Reason (R) : 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

71. **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

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

Reason (R) : H_3PO_3 is dibasic acid.

- (a) A (b) B
(c) C (d) D

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

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

- (a) A (b) B
(c) C (d) D

74. **Assertion (A) :** 1 mole 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 (R) : 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

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

Reason (R) : $1/2$ mole H_2 has produced when 1 mole of H^+ (aq) accepted 1 mole of e^- .

- (a) A (b) B
(c) C (d) D

Match the Following

Each question has two columns. Four options are given representing matching of elements from Column-I and Column- II. Only one of these four options corresponds to a correct matching. For each question, choose the option corresponding to the correct matching.

76. Match the Column I with Column II

Column - I	Column - II
(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 $\frac{N}{10^8}$ NaOH.	(s) No. of molecules of HCl left = 1.8×10^{21}

77. 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 $[Na^+] = 1.2$ M $[Cl^-] = 2.8$ 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 $[Na^+] = 0.005$ M $[Cl^-] = 0.007$ 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 $[Na^+] = 1.8$ M $[Cl^-] = 5.0$ M
(d) 100 mL of 2.0 M HCl + 200 mL of 1.0 M NaOH	(s) $[Ca^{2+}] = 1.2$ M $[Na^+] = 0.4$ M

+150 mL of 4.0 M CaCl_2 $[\text{Cl}^\ominus] = 2.8 \text{ M}$
 +50 mL of H_2O

78. Match the items given in column I with those in column II.

Column - I

Column - II

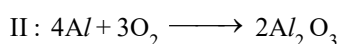
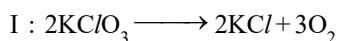
- | | |
|---|---------------------|
| (a) 9.8% H_2SO_4 by weight
(density = 1.8 g mL^{-1}) | (p) 3.6 N |
| (b) 9.8 % H_3PO_4 by weight
(density = 1.2 g mL^{-1}) | (q) 1.2 M |
| (c) 1.8 N_A molecules of
HCl is 500 mL | (r) 1.8 Equivalents |
| (d) 250 mL of 4N NaOH
+ 250 mL of
1.6 M Ca(OH)_2 | (s) 1.10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

Paragraph Type Questions

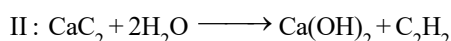
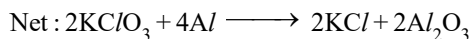
Use the following passage, solve Q. 79 to Q. 81

Passage

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.

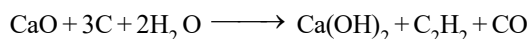


KC/O_3 decomposes in step I to give O_2 , which in turn, is used by Al to form Al_2O_3 in step II. First we determine O_2 formed in step I and then Al used by this O_2 in step II. Both reactions can be added to determine amount of KC/O_3 that can give required amount of O_2 needed for Al.



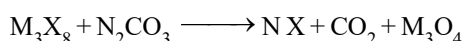
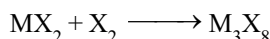
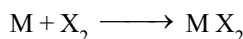
CaC_2 (calcium carbide) is prepared in step I. It is used to prepare acetylene (C_2H_2) in step II. Suppose we want to determine amount of CaO that can give enough CaC_2 to

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



Thus, $\text{CaO} \equiv \text{C}_2\text{H}_2$

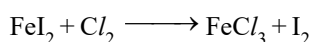
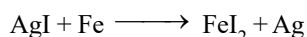
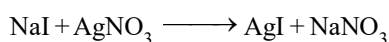
79. NX is produced by the following step of reactions



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 |

80. The following process has been used to obtain iodine from oil-field brines in California.

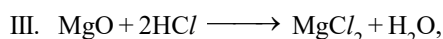
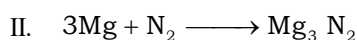
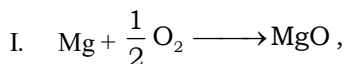


If 381 kg of iodine is produced per hour then mass of AgNO_3 required per hour will be

[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 |

81. 120 gm Mg was burnt in air to give a mixture of MgO and Mg_3N_2 . The mixture is now dissolved in HCl to form MgCl_2 and NH_4Cl , if 107 grams NH_4Cl is produced. The reaction are follows



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

Use the following passage, solve Q. 82 to Q. 84

Passage

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

82. Normality of acid is.
(a) 16.78 (b) 15.78
(c) 14.78 (d) 17.78
83. Volume of acid that contains 63g pure acid is.
(a) 100 mL (b) 40.24 mL
(c) 63.38 mL (d) 70.68 mL
84. 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

Use the following passage, solve Q. 85 to Q. 87

Passage

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 HCl is 0.1 M then equilibrium molarity of NaOH equal to zero because HCl is completely dissociated.

85. Calculate the analytical molarity of Cl^- ion in solution which is prepared by mixing 100 ml of 0.1 M NaCl and 400 ml of 0.01 M BaCl_2 .

- (a) 0.018 M (b) 0.036 M
(c) 0.084 M (d) 0.046 M

86. 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
87. HCl is 80% ionised in 0.01 M aqueous solution. The equilibrium molarity of HCl in the solution is
(a) 0.002 (b) 0.06
(c) 0.02 (d) 0.008

Use the following passage, solve Q. 88 to Q. 90

Passage

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]

88. What is the empirical formula of the salt ?
(a) $\text{K}_2\text{AlS}_2\text{O}_7$ (b) $\text{K}_2\text{Al}_2\text{S}_2\text{O}_7$
(c) KAlS_2O_8 (d) $\text{K}_3\text{AlS}_2\text{O}_{12}$
89. What is the empirical formula of the hydrated salt ?
(a) $\text{K}_2\text{AlS}_2\text{O}_7 \cdot 10\text{H}_2\text{O}$ (b) $\text{K}_2\text{Al}_2\text{S}_2\text{O}_7 \cdot 16\text{H}_2\text{O}$
(c) $\text{K}_3\text{AlS}_2\text{O}_{12} \cdot 8\text{H}_2\text{O}$ (d) $\text{KAlS}_2\text{O}_8 \cdot 12\text{H}_2\text{O}$
90. 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

EXERCISE - 4 : PREVIOUS YEAR JEE ADVANCED QUESTIONS

- The total number of electrons present in 18 ml of water (density of water is 1 g ml^{-1}) is (1980)
 - 6.02×10^{23}
 - 6.02×10^{23}
 - 6.02×10^{24}
 - 6.02×10^{25}
- If 0.5 mol of BaCl_2 is mixed with 0.2 mol of Na_3PO_4 , the maximum number of moles of $\text{Ba}_3(\text{PO}_4)_2$ that can be formed is (1981)
 - 0.7
 - 0.5
 - 0.30
 - 0.10
- 3 g of a salt of molecular weight 30 is dissolved in 250 g of water. The molality of the solution is : (1983)
- A sugar syrup of weight 214.2 g contains 34.2 g of sugar ($\text{C}_{12}\text{H}_{22}\text{O}_{11}$). Calculate : (i) molal concentration and (ii) mole fraction of sugar in the syrup. (1988)
- The weight of 1×10^{22} molecules of $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ is (1991)
 - 41.59 g
 - 415.9 g
 - 4.159 g
 - none of the three
- The sulphate of a metal M contains 9.87% of M. This sulphate is isomorphous with $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$. The atomic weight of M is (1991)
 - 40.3
 - 36.3
 - 24.3
 - 11.3
- The normality of 0.3 M phosphorous acid (H_3PO_3) is (1999)
 - 0.1
 - 0.9
 - 0.3
 - 0.6
- 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)
 - 40 mL
 - 20 mL
 - 10 mL
 - 4 mL
- Mixture X = 0.02 mole of $[\text{Co}(\text{NH}_3)_5\text{SO}_4]\text{Br}$ and 0.02 mole of $[\text{Co}(\text{NH}_3)_3\text{Br}]\text{SO}_4$ 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)
 - 0.01, 0.01
 - 0.02, 0.01
 - 0.01, 0.02
 - 0.02, 0.02
- Which has maximum number of atoms ? (2003)
 - 24g of C (12)
 - 56g of Fe (56)
 - 27g of Al (27)
 - 108g of Ag (108)
- In a solution of 100 ml of 0.5M 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 $3.01 \times 10^2 \text{ m}^2$, calculate the area occupied by single acetic acid molecule on surface of charcoal. (2003)
- Calculate the molarity of water if its density is 1000 kg/m^3 . (2003)
- 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 $6.023 \times 10^{14}/\text{cm}^2$ and surface area is 1000 cm^2 , find out the number of surface sites occupied per molecule of N_2 . (2005)
- Given that the abundances of isotopes Fe_{54} , Fe_{56} and Fe_{57} are 5%, 90% and 5%, respectively, the atomic mass of Fe is (2009)
 - 55.85
 - 55.95
 - 55.75
 - 56.05
- 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)
 - 1.78 M
 - 2.00 M
 - 2.05 M
 - 2.22 M
- 29.2% (w/W) HCl stock solution has density of 1.25 g mL^{-1} . The molecular weight of HCl is 36.5 g mol^{-1} . The volume (mL) of stock solution required to prepare a 200 mL solution 0.4 M HCl is (2013)
- 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)

18. The mole fraction of a solute in a solution is 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, $\left(\frac{MW_{\text{solute}}}{MW_{\text{solvent}}} \right)$, is (2016)
19. 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)
20. Aluminium reacts with sulfuric acid to form aluminium sulfate and hydrogen. What is the volume of hydrogen gas in litres (L) produced at 300 K and 1.0 atm pressure, when 5.4 g of aluminium and 50.0 mL of 5.0 M sulfuric acid are combined for the reaction?
(Use molar mass of aluminium as 27.0 g mol^{-1} , $R = 0.082 \text{ atm, L mol}^{-1} \text{ K}^{-1}$) (2020)

ANSWER KEY

CHAPTER -4 | MOLE AND EQUIVALENT CONCEPTS

EXERCISE - 1: BASIC OBJECTIVE QUESTIONS

EXERCISE - 2: PREVIOUS YEAR JEE MAINS QUESTIONS

- | | | | | |
|---------|---------|---------|---------|---------|
| 1. (c) | 2. (b) | 3. (a) | 4. (a) | 5. (c) |
| 6. (c) | 7. (b) | 8. (b) | 9. (c) | 10. (a) |
| 11. (d) | 12. (a) | 13. (a) | 14. (d) | 15. (b) |
| 16. (b) | 17. (b) | 18. (a) | 19. (b) | 20. (d) |
| 21. (a) | 22. (a) | 23. (b) | 24. (d) | 25. (c) |
| 26. (b) | 27. (b) | 28. (a) | 29. (a) | 30. (a) |
| 31. (b) | 32. (b) | 33. (c) | 34. (a) | 35. (c) |
| 36. (d) | 37. (d) | 38. (b) | 39. (c) | 40. (c) |
| 41. (d) | 42. (c) | 43. (d) | 44. (a) | 45. (b) |
| 46. (d) | 47. (c) | 48. (c) | 49. (d) | 50. (c) |
| 51. (c) | 52. (d) | 53. (b) | 54. (a) | 55. (b) |
| 56. (a) | 57. (d) | 58. (c) | 59. (b) | 60. (c) |
| 61. (c) | 62. (a) | 63. (b) | 64. (b) | 65. (d) |
| 66. (a) | 67. (b) | 68. (d) | 69. (c) | 70. (d) |
| 71. (d) | 72. (b) | 73. (b) | 74. (a) | 75. (b) |
| 76. (d) | 77. (a) | 78. (a) | 79. (c) | 80. (b) |
| 81. (b) | 82. (b) | 83. (c) | 84. (d) | 85. (c) |
| 86. (c) | 87. (b) | 88. (a) | 89. (a) | 90. (a) |
| 91. (a) | 92. (a) | 93. (b) | 94. (c) | 95. (b) |

- | | | | | |
|---------------|---------|--------------|---------|-------------|
| 1. (a) | 2. (a) | 3. (c) | 4. (b) | 5. (a) |
| 6. (c) | 7. (d) | 8. (d) | 9. (b) | 10. (c) |
| 11. (c) | 12. (d) | 13. (a) | 14. (a) | 15. (b) |
| 16. (b) | 17. (a) | 18. (a) | 19. (c) | 20. (c) |
| 21. (b) | 22. (a) | 23. (c) | 24. (b) | 25. (a) |
| 26. (c) | 27. (c) | 28. (a) | 29. (c) | 30. (8.4) |
| 31. (a) | 32. (d) | 33. (c) | 34. (d) | 35. (b) |
| 36. (a) | 37. (b) | 38. (a) | 39. (d) | 40. (13.88) |
| 41. (d) | 42. (c) | 43. (b) | | |
| 44. (26.92) | | 45. (37.84) | | |
| 46. (5.00) | | 47. (47.00) | | |
| 48. (3400.00) | | 49. (18.00) | | |
| 50. (8.00) | | 51. (8.00) | | |
| 52. (13.00) | | 53. (3.00) | | |
| 54. (525.00) | | 55. (80.00) | | |
| 56. (1.00) | | 57. (77.00) | | |
| 58. (18.00) | | 59. (16.00) | | |
| 60. (3.00) | | 61. (78.00) | | |
| 62. (226.0) | | 63. (1.00) | | |
| 64. (4.00) | | 65. (464.00) | | |
| 66. (3.00) | | 67. (5.00) | | |
| 68. (0.5 M) | | 69. (19.00) | | |
| 70. (20.00) | | 71. (2.00) | | |
| 72. (64.00) | | 73. (d) | | |
| 74. (78.00) | | 75. (13.00) | | |

CHAPTER -4| MOLE AND EQUIVALENT CONCEPTS

EXERCISE - 3 : ADVANCED OBJECTIVE QUESTIONS

EXERCISE - 4 : PREVIOUS YEAR JEE ADVANCED QUESTIONS

1. (c) 2. (b) 3. (d) 4. (c) 5. (b)
6. (c) 7. (c) 8. (b) 9. (d) 10. (a)
11. (c) 12. (c) 13. (a) 14. (b) 15. (c)
16. (c) 17. (b) 18. (a) 19. (d) 20. (c)
21. (b) 22. (d) 23. (a) 24. (b) 25. (a)
26. (c) 27. (a) 28. (b) 29. (a) 30. (b)
31. (d) 32. (b) 33. (d) 34. (c) 35. (a,c,d)
36. (a,b) 37. (b,c) 38. (a,b) 39. (b,c) 40. (a,b,d)
41. (a,c) 42. (a,b) 43. (a,b,c,d)
44. (a,b,c) 45. (a,b,d)
46. (a,b,c,d) 47. (b,c)
48. (a,b,c,d) 49. (b,c,d)
50. (a,b,d) 51. (a,b,c,d)
52. (a,b,c) 53. (a,c,d)
54. (a,b) 55. (5.00)
56. (79.75) 57. (59.4%)
58. (14.5%) 59. (60.3%)
60. (8g) 61. (10.00)
62. (9.00) 63. (45.04%)
64. (a) 65. (c)
66. (a) 67. (a)
68. (d) 69. (a)
70. (d) 71. (a)
72. (d) 73. (d)
74. (b) 75. (a)
76. (a-q; b-q; c-s; d-r) 77. (a-q; b-p; c-r; d-s)
78. (a-p,s; b-p,q; c-p,r; d-r) 79. (a) 80. (d)
81. (c) 82. (b) 83. (c) 84. (a) 85. (b)
86. (a) 87. (a) 88. (c) 89. (d) 90. (b)

1. (c) 2. (d) 3. (0.4m)
4. (i) 0.56, (ii) 0.0099
5. (c) 6. (c) 7. (d) 8. (a) 9. (a)
10. (a) 11. ($5 \times 10^{-19} \text{ m}^2$) 12. (55.55 M)
13. (2.00) 14. (b) 15. (c) 16. (8.00) 17. (8.00)
18. (9.00) 19. (6.47) 20. (6.15)