CHAPTER > 01

Some Basic Concepts of Chemistry

KEY NOTES

Development of Chemistry

- In ancient India, chemistry was called *Rasayan Shastra, Rastantra, Ras Kriya or Rasvidya.*
- According to Rigveda, tanning of leather and dyeing of cotton were practised during 1000-400 BCE.
- *Kautilya's Arthashastra* describes the production of salt from sea. It also mentions about many type of liquors.
- *Sushruta Samhita* explains the importance of alkalies.
- The *Charaka Samhita* mentions ancient Indians who knew how to prepare sulphuric acid, nitric acid and oxides of copper, tin and zinc, the sulphates of copper, zinc and iron and the carbonates of lead and iron.
- *Rasopanishada* describes the preparation of gunpowder mixture.
- Nagarjuna's work *Rasratnakar* deals with the formulation of mercury compounds. He has also discussed methods for the extraction of metals like gold, silver, tin and copper.
- *Chakrapani* discovered mercury sulphide. He used mustard oil and some alkalies as ingredients for making soap.
- *Brihat Samhita* informs about the preparation of glutinous material to be applied on walls and roofs of houses and temples. It also gives references to perfumes and cosmetics.
- *Atharvaveda* mention some dye stuff. The material used were turmeric, madder, sunflower, lac etc.
- *Acharya Kanda* was first proponent of atomic theory. According to him, all substances are aggregated form of smaller units called atoms which are eternal, indestructible, spherical, suprasensible and in motion in the original state.

Importance of Chemistry

- **Principles of chemistry** are applicable in diverse areas such as weather patterns, functioning of brain and operation of chemical industries, manufacturing fertilisers, alkalis, acids, salts dyes, polymers, drugs, soaps, detergents, metals, alloys etc.
- **Chemistry** provides methods for isolation of life saving drugs from natural sources and makes possible synthesis of such drugs. Some of these drugs are **cisplatin** and **taxol** which are effective in cancer therapy. The drug AZT is used for helping AIDS patients.
- Safer alternatives to environmentally hazardous refrigerants like CFC's responsible for ozone depletion in the stratosphere have been successfully synthesised.

Nature and Classification of Matter

- Anything that occupies space and has mass is called **matter**. All substances contain matter on physical basis, it can be classified into solid, liquid and gases.
  (i) In **solid,** the particles are held very close to each other in an orderly fashion and there is not much freedom of movement. Due to such arrangement, solids have definite volume and definite shape.
  (ii) In **liquids,** the particles are close to each other but they can move around. Liquids possess definite volume but do not possess definite shape. They take the shape of the container in which they are placed.
  (iii) In **gases,** the particles are far apart as compared to those present in solid or liquid states and their movement is easy and fast. Gases have neither definite volume nor definite shape.
- These **three states of matter are interconvertible**, by changing the condition of temperature and pressure.

$$\text{Solid} \underset{\text{Cool}}{\overset{\text{Heat}}{\rightleftharpoons}} \text{liquid} \underset{\text{Cool}}{\overset{\text{Heat}}{\rightleftharpoons}} \text{Gas}$$

- On the basis of chemical composition, matter is classified as mixture or pure substances.
- **Mixture** contains particles of two or more pure substances which may be present in it in any ratio. Their composition is variable. A mixture may be homogeneous or heterogeneous.
  - In a **homogeneous mixture,** the components completely mix with each other. This means, the particles of components of the mixtures are uniformly distributed throughout the bulk of the mixture and its composition is uniform throughout. e.g. salt dissolved in water.
  - In a **heterogeneous mixture,** the composition is not uniform throughout and sometimes different components are visible. e.g. salt and sand in water.
- **Pure substances** have different characteristic from mixtures. Constituent particles of pure substances have fixed composition.
  - These can further be classified into **elements** and **compounds.**
  - Particles of an **element** consist of only one type of atoms. These particles may exist as atoms or molecules.
  - Some elements such as sodium or copper contain atoms as their constituents particles and their all atoms are of same type, where in some others such as hydrogen, nitrogen and oxygen, the constituent particles are molecules which are formed by two or more atoms.
  - When two or more atoms of different elements combine together in a definite ratio, the **molecule** of a compound is obtained. The constituents of a compound cannot be separated into simpler substances by physical methods. However, these can be separated by chemical methods.
  - The **atoms** of different elements are present in a compound in a fixed and definite ratio. The properties of a compound are different from those of its constituent elements.

Properties of Matter and their Measurement

Each substance is associated with some unique set of characteristics, which are collectively called the **properties of matter**.

The properties of matter are categorised into two types :

Physical Properties

Those properties which can be measured or observed without changing the identity or the composition of the substance are called **physical properties**. e.g. colour, odour, melting point, boiling point, density etc.

Chemical Properties

Those properties which require a chemical change to occur for their measurement or observation are known as **chemical properties**. e.g. characteristic reactions of different substances ; acidity, basicity, combustibility etc.

Measurements of Physical Properties

Quantitative measurements of properties is required for scientific investigation. Many properties of matter like length, area or volume are quantitative in nature and is represented by a number followed by units in which it is measured.
For example, length of a room can be shown as 6 m.

The International System of Units (SI)

Many systems or measurements exist among them the **English and the metric systems** are widely used. The scientific community has agreed to have a uniform and common system throughout the world which is abbreviated as SI units.

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 the weight may vary from one place to another due to change in gravity.
- The SI unit of mass is kilogram (kg). The mass of a substance can be determined accurately by using analytical balance.

Volume

- It is the amount of space occupied by a substance. In SI system, volume has units of m^3.
- In laboratory, the volumes of liquids or solutions can be measured by graduated cylinders, burette, pipette etc.
- A volumetric flask is used to prepare a known volume of a solution.

Density

- Density of a substance is the amount of mass per unit volume.
- SI units of density is $kg\ m^{-3}$.
- Density of a substance tells us about how closely its particles are packed. If density is more, it means particles are more closely packed.

Temperature

- Temperature is the measure of hotness or coldness of a body.
- There are three common scales to measure temperature °C (degree Celsius), °F (degree Fahrenheit) and K (Kelvin). The SI unit of temperature is K.
- The temperature on Fahrenheit scale and Celsius scale are related to each other by following relationship :

$$°F = \frac{9}{5}(°C) + 32$$

- The Kelvin scale is related to Celsius scale as follows :

$$K = °C + 273.15$$

- Temperature below 0°C are possible in Celsius scale but in Kelvin scale, negative temperature is not possible.

Uncertainty in Measurement

- A convenient system of expressing the numbers in **scientific notation** is used, i.e. exponential notation in, which any number can be represented in the form $N \times 10^n$, where n is an exponent having positive or negative values and N is a number which varies between 1.000 and 9.999.

- In **addition and subtraction,** first the number are written in such a way that they have the same exponents. After that, the coefficients are added or subtracted as the case may be.
- **Multiplication and division** operation follow the same rule.
- **Significant figures** are the meaningful digits which are known with certainty plus one which is estimated or uncertain.
- **Precision** refers to the closeness of various measurements for the same quantity. **Accuracy** is the agreement of a particular value to the true value of the result.
- While **addition and subtraction** of significant figures, the result cannot have more digits to the right of the decimal point than either of the original numbers.
- All non-zero digits or zero present between two non-zero digits are **significant**. Zeroes on the left side of a number are never significant, while that on right side, if present after a decimal point, are significant.
- In **multiplication and division** of significant figures, the result must be reported with no more significant figures as in the measurement with the few significant figures.
- The method used to convert units from one system to the other is called **factor label method** or **unit factor method** or **dimensional analysis.**

Laws of Chemical Combinations

Elements combine to form molecules in accordance to the following five basic laws of chemical combinations.

→ Law of conservation of mass **Antoine Lavoisier**

Matter can neither be created nor be destroyed during the course of a chemical reaction, however its physical and chemical nature may change.

→ Law of definite proportions **Joseph Proust**

It is also called as low of definite composition.
A given compound always contains exactly the same proportion of elements by weight.

→ Law of multiple proportions **John Dalton**

If two elements can combine to form more than one compound, the masses of one element that combine with a fixed mass of the other element, are in the ratio of small whole numbers.

→ Law of gaseous volumes **Gay Lussac**

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.

→ Avogadro's law **Avogadro**

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

Dalton's Atomic Theory

- **Dalton** proposed **atomic theory** in which he proposed the following :
  (i) Matter consists of indivisible atoms.
  (ii) All the atoms of a given element have identical properties including identical mass. Atoms of different elements differ in mass.
  (iii) Compounds are formed when atoms of different elements combine in a fixed ratio.
  (iv) Chemical reactions involve reorganisation of atoms. These are neither created nor destroyed in a chemical reaction.
- **Dalton's theory** could explain the laws of chemical combination. However, it could not explain the law of gaseous volumes. It could not provide the reason for combining of atoms.

Atomic and Molecular Masses

- The present system of atomic masses is based on carbon-12 (^{12}C) as the standard which is one of the isotopes of carbon.
- In this system, ^{12}C is assigned a mass of exactly 12 atomic mass unit and masses of all other atoms are given relative to this standard.
- **One atomic mass unit** is defined as a mass exactly equal to one-twelfth of the mass of one carbon-12 atom. At present, 'amu' has been replaced by 'u' which is known as unified mass.

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

- Many naturally occurring elements exist as more than one isotope. When we take into account the existence of these isotopes and their relative abundance, the **average atomic mass** of the element can be computed.
- **Molecular mass** is the sum of atomic masses of the elements present in a molecule. It is obtained by multiplying the atomic mass of each element by the number of its atom and adding them together.
- Some substances such as sodium chloride do not contain discrete molecules as their constituent units. The formula such as NaCl is used to calculate the **formula mass** instead of molecular mass as in the solid state sodium chloride does not exist as a single entity.

Mole Concept and Molar Masses

- **One mole** is the amount of a substance that contains as many particles or entities as there are atoms in exactly 12g of the ^{12}C isotope.
- 6.022×10^{23} this number is called **Avogadro's number or Avogadro's constant.** It is denoted by N_A.
- The mass of one mole of a substance in grams is called its **molar mass** which is numerically equal to atomic/molecular/formula mass in u.

- For determining the **percentage composition** of each element in a compound.

  Mass % of an element

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

Empirical and Molecular Formula

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

Short Trick to Find Empirical and Molecular Formula

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

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

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

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

Step 5 Multiply empirical formula by n to obtain molecular formula $\left(n = \frac{\text{Molecular mass}}{\text{Empirical formula mass}}\right)$

Stoichiometry and Stoichiometric Calculations

- **Stoichiometry** deals with the calculation of masses of the reactants and products involved in a chemical reaction. It can be determined with the knowledge of balanced chemical equation.
- A balanced chemical equation has the same number of atoms of each element on both sides of the equation.
- In the balanced reaction,

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

  the coefficients 2 for O_2 and H_2O are called **stoichiometric coefficients.** Similarly, for CH_4 and CO_2, stoichiometric coefficients are 1 only.
- According to the above chemical reaction,
  - (i) One mole of $CH_4(g)$ reacts with two moles of $O_2(g)$ to give one mole of $CO_2(g)$ and two moles of $H_2O(g)$.
  - (ii) One molecule of $CH_4(g)$ reacts with 2 molecules of $O_2(g)$ to give one molecule of $CO_2(g)$ and 2 molecules of $H_2O(g)$.
  - (iii) 22.7 L of $CH_4(g)$ reacts with 45.4 L of $O_2(g)$ to give 22.7 L of $CO_2(g)$ and 45.4 L of $H_2O(g)$.
  - (iv) 16 g of $CH_4(g)$ reacts with 2×32 g of $O_2(g)$ to give 44g of CO_2 and 2×18 g of $H_2O(g)$.
- The reactant which gets consumed first and limits the amount of product formed in a chemical reaction is called the **limiting reagent.**

Reactions in Solutions

- The **concentration of solution** or the amount of substance present in its given volumes can be expressed in any of the following ways shown in below table:

Comparison between Concentration Terms

	Mass per cent	Mole fraction (χ)	Molality (m)	Molarity (M), Formality (F)
Definition	The mass of a component per 100g of the solution.	The ratio of number of moles of a particular component to the total number of moles of the solution.	The number of moles of solute present in 1 kg of solvent.	The number of moles of the solute in 1 litre of the solution.
Formula	$\frac{w_{\text{solute}}}{w_{\text{solution}}} \times 100$	$\chi_{\text{solute}} = \frac{n_{\text{solute}}}{n_{\text{solute}} + n_{\text{solvent}}} \times 100$ $\chi_{\text{solvent}} = \frac{n_{\text{solvent}}}{n_{\text{solute}} + n_{\text{solvent}}} \times 100$ $\chi_{\text{solute}} + \chi_{\text{solvent}} = 1$	$m = \frac{n_{\text{solute}}}{w_{\text{solvent}}\text{ (in g)}} \times 1000$ $= \frac{w_{\text{solute}}\text{(in g)} \times 1000}{Mw_{\text{solute}} \times w_{\text{solvent}}\text{ (in g)}}$	$M \text{ or } F = \frac{n_{\text{solute}}}{V_{\text{solution}}\text{ (in L)}}$ M or F $= \frac{w_{\text{solute}}\text{(in g)}}{Mw_{\text{solute}}/Fw_{\text{solvent}} \times V_{\text{solution}}\text{ (in L)}}$ $M = \frac{w_{\text{solute}}\% \times d_{\text{solution}} \times 10}{M_{\text{solute}}}$
Units	Unitless	Unitless	mol/kg	mol/L

Note *Molarity of solution after dilution,* $M_1V_1 = M_2V_2$

Mastering NCERT

MULTIPLE CHOICE QUESTIONS

TOPIC 1 ~ Development, Importance of Chemistry and Nature of Matter

1 Chemistry was not studied for its own sake, rather it came up as a result of search for
(a) Philosopher's stone
(b) Elexir of life
(c) Paras
(d) All of the above

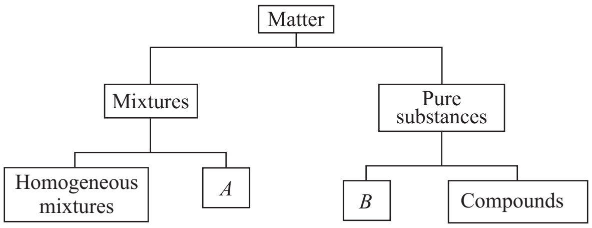
2 Which of the following is not described in Charaka Samhita?
(a) Preparation of nitric acid and oxides of Cu, Sn and Zn.
(b) Use of various parts of plant for the preparation of Asavas.
(c) Preparation of perfumes and cosmetics.
(d) Use of Bhasma of metals for treatment of ailments

3 Who among the following was the first proponent of atomic theory?
(a) Acharya Kanda
(b) Chakrapani
(c) Nagarjuna
(d) None of the above

4 The two effective drugs which act as life saving drugs for cancer therapy and AIDS victims respectively are
(a) AZT (azidothymidine) and taxol.
(b) taxol and cisplatin.
(c) taxol and AZT (azidothymidine).
(d) AZT (azidothymidine) and cisplatin.

5 Which of the following environmentally hazardous refrigerant responsible for ozone depletion in the stratosphere?
(a) CFCs (Chlorofluorocarbons)
(b) CFM (Chlorofluoromethane)
(c) CC (Chloroiodocarbons)
(d) CIM (Chloroiodomethane)

6 Matter can be classified as mixtures or pure substances. These can be further sub-divided as shown.



The missing terms A and B respectively are
(a) $A \rightarrow$ microscopic level, $B \rightarrow$ heterogeneous mixtures
(b) $A \rightarrow$ heterogeneous mixtures, $B \rightarrow$ elements
(c) $A \rightarrow$ homogeneous mixtures, $B \rightarrow$ elements
(d) $A \rightarrow$ elements, $B \rightarrow$ heterogeneous mixtures

7 Which of the following is not a mixture?
(a) Gasoline (b) Distilled alcohol
(c) LPG (d) Iodised table salt

TOPIC 2 ~ Properties of Matter and their Measurement with Uncertainty in Measurement

8 Any quantitative observation or measurement is represented by A followed by B in which it is measured. A and B respectively are
(a) $A \rightarrow$ units, $B \rightarrow$ number
(b) $A \rightarrow$ alphabet, $B \rightarrow$ units
(c) $A \rightarrow$ number, $B \rightarrow$ units
(d) $A \rightarrow$ roman numeral, $B \rightarrow$ number

9 Consider the following units of energy, A : 1 L atm, B : 1 erg, C : 1 J, D : 1 kcal, increasing order of these values is
(a) $A = B = C = D$ (b) $A < B < C < D$
(c) $B < C < A < D$ (d) $D < A < C < B$

10 A measured temperature on Fahrenheit scale is 200°F. What will this reading be on Celsius scale?
(a) 40°C (b) 94°C (c) 93.3°C (d) 30°C

11 The scientific notation of some figures are given below. Which of the following options is not correct?
(a) $8008 = 8.008 \times 10^3$ (b) $208 = 2.08 \times 10^3$
(c) $5000 = 5.0 \times 10^3$ (d) $0.0034 = 3.4 \times 10^3$

12 In scientific notation, 0.00016 can be written as
(a) 1.6×10^{-4} (b) 1.6×10^{-3} (c) 1.6×10^{-2} (d) 1.6×10^{-1}

13 The addition of number 6.65×10^{4} and 8.95×10^{3} and substraction of numbers $2.5\times10^{-2}-4.8\times10^{-3}$, respectively in terms of scientific notation will be
(a) $7.545\times10^{4}, 2.02\times10^{-2}$ (b) $75.43\times10^{3}, 2.02\times10^{-3}$
(c) $745.5\times10^{2}, 2.02\times10^{-1}$ (d) $75.45\times10^{0}, 2.02\times10^{0}$

14 The number of significant figures in Avogadro's number is
(a) four (b) two (c) three (d) None of these

15 *A* refers to the closeness of various measurements for the same quantity. *B* is the agreement of a particular value to the true value of the result. *A* and *B* respectively are
(a) $A\rightarrow$ significant figures, $B\rightarrow$ accuracy
(b) $A\rightarrow$ accuracy, $B\rightarrow$ precision
(c) $A\rightarrow$ precision, $B\rightarrow$ accuracy
(d) $A\rightarrow$ significant figures, $B\rightarrow$ precision

16 Which of the following is the most accurate measurement?
(a) 9 m (b) 9.0 m (c) 9.00 m (d) 9.000 m

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

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

Which of the following students got the values which are both precise and accurate?
(a) Student *A* (b) Student *B*
(c) Student *C* (d) None of these

18 Look at the addition of significant figures given below.

12.11
18.0
1.012
31.122

The result reported in this addition should be
(a) 31.12 (b) 31.1 (c) 31.122 (d) 31.10

19 The result reported in the following multiplication of significant figures, $2.5\times1.25=3.125$ should be
(a) 3.125 (b) 3.1 (c) 3.12 (d) 3.10

20 18.72 g of a substance *X* occupies 1.81 cm^3. What will be its density measured in correct significant figures?
(a) 10.3 g/cm^3 (b) 10.34 g/cm^3
(c) 10.4 g/cm^3 (d) 10.3425 g/cm^3

21 If 6.25 is to be rounded off to *A* and if 6.35 is to be rounded off to *B*. Here, *A* and *B* refer to
(a) $A\rightarrow6.2, B\rightarrow6.4$ (b) $A\rightarrow6.1, B\rightarrow6.3$
(c) $A\rightarrow6.3, B\rightarrow6.4$ (d) $A=6.1, B=6.2$

22 The result of which of the following has/have least significant figure(s)?
(a) $\frac{0.02856\times298.15\times0.112}{0.5785}$
(b) 5×5.364
(c) $0.0125+0.7864+0.0215$
(d) All have same number of significant figures.

23 Often, while calculating, there is a need to convert units from one system to other. The method used to accomplish is called
(a) factor label method (b) unit factor method
(c) dimensional analysis (d) All of these

24 The unit (JPa^{-1}) is equivalent to
(a) m^3 (b) cm^{-3}
(c) dm^3 (d) None of these

25 Few quantities with their units are given below. Mark the unit which is not correctly converted.
(a) 1 km = 10^6 mm (b) 1 mg = 10^{-6} kg
(c) 1 mg = 10^{10} ng (d) 1 mL = $10^{-3}dm^3$

26 Mark the conversion factor which is not correct.
(a) 1 inch = 2.54 cm (b) 1 Litre = $10^{-3}m^3$
(c) 1 m = 3.937 inches (d) 1 atm = 1.01325×10^5 Pa

27 Which set of figures will be obtained after rounding upto three significant figures 1.386, 4.334, 28.08 ?
(a) 1.39, 4.34, 280 (b) 1.39, 4.33, 28.1
(c) 1.38, 4.34, 280 (d) 1.39, 4.34, 281

28 A jug contains 5 L of milk. Calculate the volume of milk in m^3.
(a) 5×10^{-3} (b) 5×10^{3} (c) 5×10000 (d) 5×10^{5}

29 The correct conversion of the following into basic units.
(i) 28.7 pm (ii) 15.15 μs (iii) 25365 mg
(a) (i) $\rightarrow28.7\times10^{-11}$ m, (ii) $\rightarrow1.515\times10^{-6}$ s, (iii) $\rightarrow2.5365\times10^{-3}$ kg
(b) (i) $\rightarrow2.87\times10^{-11}$ m, (ii) $\rightarrow1.515\times10^{-5}$ s, (iii) $\rightarrow2.5365\times10^{-2}$ kg
(c) (i) $\rightarrow2.87\times10^{-10}$ m, (ii) $\rightarrow1.515\times10^{-5}$ s, (iii) $\rightarrow2.5365\times10^{-3}$ kg
(d) (i) $\rightarrow2.87\times10^{-10}$ m, (ii) $\rightarrow1.515\times10^{-6}$ s, (iii) $\rightarrow2.5365\times10^{-2}$ kg

30 A student performs a titration with different burettes and finds titrate values of 25.2 mL, 25.25 mL and 25.0 mL. The number of significant figures in the average titrate value is
(a) 1 (b) 2 (c) 3 (d) 4

TOPIC 3 ~ *Laws of Chemical Combinations*

31 4.88 g of $KClO_3$ when heated, produces 1.92 g of O_2 and 2.96 g of KCl. Which law is illustrated by the above experiment?
(a) The result illustrates the law of conservation of mass
(b) The result illustrates the law of multiple proportion
(c) The result illustrates the law of constant proportion
(d) None of the above

32 If 6.3 g of $NaHCO_3$ are added to 15.0 g CH_3COOH solution, the residue is found to weigh 18.0 g. What will be the mass of CO_2 released in the reaction?
(a) 4.5 g (b) 3.3 g (c) 2.6 g (d) 2.8 g

33 Proust worked with the two samples of cupric carbonate, one of which was of natural origin and the other was synthetic one. He found that, the composition of elements present in it was same for both the samples as shown below.

Sample	% of Cu	% of O_2	% of C
Natural sample	51.35	9.74	38.91
Synthetic sample	51.35	9.74	38.91

Which law is in favour of the above data?
(a) Law of multiple proportions
(b) Gay Lussac's law of gaseous volumes
(c) Avogadro's law
(d) Law of definite proportions

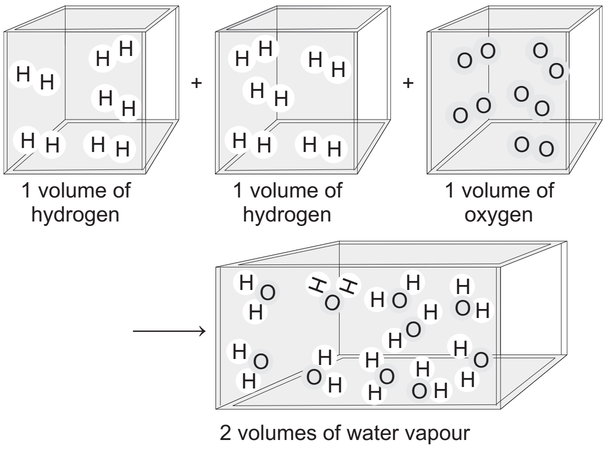
34 Zinc sulphate contains 22.65% zinc and 43.9% water of crystallisation. If the law of constant proportions is true then the weight of zinc required to produce 20 g of the zinc sulphate crystals will be
(a) 45.3 g (b) 4.53 g (c) 0.453 g (d) 453 g

35 The pairs which illustrate the law of multiple proportions is
(a) PH_3, HCl (b) $CuCl_2$, $CuSO_4$
(c) PbO, PbO_2 (d) H_2S, SO_2

36 Which of the following statements illustrate the law of multiple proportions?
(a) 3.47 g of $BaCl_2$ reacts with 2.36 g Na_2SO_4 to give 3.88 g $BaSO_4$ and 1.95 g NaCl.
(b) Hydrogen sulphide contains 5.89% hydrogen, water contains 11.1% hydrogen and sulphur dioxide contains 50% oxygen.
(c) An element forms two oxides, *X*O and XO_2 containing 50% and 60% oxygen respectively. The ratio of masses of oxygen which combines with 1 g of element is 2 : 3.
(d) 20 mL ammonia gives 10 volumes N_2 and 30 volumes H_2 at constant temperature and pressure.

37 According to Avogadro's law, two volumes of hydrogen combine with one volume of oxygen to give two volumes of water without leaving any
(a) mass of oxygen. (b) residual mass of oxygen.
(c) reacted oxygen. (d) unreacted oxygen.

38 Consider the given figure,



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

$$\underset{100\text{ mL}}{\text{Hydrogen}} + \underset{A}{\text{Oxygen}} \longrightarrow \underset{100\text{ mL}}{\text{Water}}$$

The volumes of hydrogen and oxygen which combine together bear a simple ratio of …*B*… .
The missing terms *A* and *B* respectively are
(a) $A \to 25$ mL, $B \to 1:2$
(b) $A \to 50$ mL, $B \to 1:2$
(c) $A \to 50$ mL, $B \to 2:1$
(d) $A \to 25$ mL, $B \to 2:1$

TOPIC 4 ~ *Dalton's Atomic Theory, Atomic and Molecular Masses*

39 Given that, the abundances of isotopes ^{54}Fe, ^{56}Fe and ^{57}Fe are 5%, 90% and 5% respectively, the average atomic mass of Fe (in percentage) is
(a) 55.85 (b) 55.95 (c) 55.75 (d) 56.05

40 A bivalent metal has an atomic mass of 64u. The molecular mass of the metal nitrate is
(a) 182 (b) 168
(c) 192 (d) 188

41 An alkaloid contains 17.28% of nitrogen and its molecular mass is 162. The number of nitrogen atoms present in one molecule of alkaloid is
(a) 5 (b) 4 (c) 3 (d) 2

42 Oxygen occurs in nature as a mixture of isotopes ^{16}O, ^{17}O and ^{18}O having atomic masses of 15.995 u, 16.999 u and 17.999 u and relative abundance of 99.763%, 0.037% and 0.200% respectively. What is the average atomic mass of oxygen?
(a) 15.999 u (b) 16.999 u (c) 17.999 u (d) 18.999 u

43 Carbon has the following three isotopes with relative abundances and masses (amu) shown in the table.

Isotopes	Relative abundance (%)	Atomic mass (amu)
^{12}C	98.892	12
^{13}C	1.108	13.00335
^{14}C	2×10^{-10}	14.00317

On the basis of above data, the average atomic mass of carbon will be
(a) 12.000 u (b) 12.011 u
(c) 12.015 u (d) 13.000 u

44 In sodium chloride, one Na^+ ion is surrounded by
(a) $2Cl^-$ ions (b) $4Cl^-$ ions
(c) $12Cl^-$ ions (d) $6Cl^-$ ions

TOPIC 5 ~ Mole Concept, Molar Mass and Percentage Composition

45 '*X*' is the amount of a substance that contains as many particles as there are atoms in exactly 12 g of the *Y* isotope. *X* and *Y* respectively are
(a) $A \rightarrow$ one mole, $B \rightarrow {}^{14}C$
(b) $A \rightarrow$ percentage composition, $B \rightarrow {}^{12}C$
(c) $A \rightarrow$ one mole, $B \rightarrow {}^{12}C$
(d) $A \rightarrow$ percentage composition, $B \rightarrow {}^{14}C$

46 In order to determine the mole precisely, the mass of a carbon *A* was determined by a *B* and found to be equal to *C* g. *A, B* and *C* respectively are
(a) $A \rightarrow$ 12 atom, $B \rightarrow$ mass spectrometer, $C \rightarrow 1.992648\times10^{-23}$
(b) $A \rightarrow$ 14 atom, $B \rightarrow$ atomic spectrometer, $C \rightarrow 1.992648\times10^{-21}$
(c) $A \rightarrow$ 1 mole, $B \rightarrow$ Infrared spectrometer, $C \rightarrow 1.992648\times10^{-20}$
(d) $A \rightarrow$ 12 atom, $B \rightarrow$ mass spectrometer, $C \rightarrow 1.992\times10^{-19}$

47 25 g of an unknown hydrocarbon upon burning produces 88 g of CO_2 and 9 g of H_2O. This unknown hydrocarbon contains ***JEE Main 2019***
(a) 20 g of carbon and 5 g of hydrogen
(b) 22 g of carbon and 3 g of hydrogen
(c) 24 g of carbon and 1 g of hydrogen
(d) 18 g of carbon and 7 g of hydrogen

48 What will be the weight of CO having the same number of O-atoms as present in 22 g of CO_2?
(a) 28 g (b) 22 g (c) 44 g (d) 72 g

49 How many number of aluminium ions are present in 0.051 g of aluminium oxide?
(a) 6.023×10^{23} ions (b) 3 ions
(c) 6.023×10^{20} ions (d) 9 ions

50 A sample of ammonia phosphate, $(NH_4)_3PO_4$ contains 6.36 moles of H-atoms. The number of moles of O-atom in the sample is
(Atomic mass of N = 14.04, H = 1, P = 31 and O = 16)
(a) 0.265 (b) 0.795 (c) 2.12 (d) 4.14

51 A cylinder of compressed gas contains nitrogen and oxygen in the ratio 3:1 by mole. If the cylinder is known to contain 2.5×10^4 g of oxygen, what is the total mass of the gas mixture?
(a) 781.25 (b) 6.5625×10^4
(c) 9.0625×10^4 (d) 6.023×10^5

52 If 1 mL of water contains 20 drops then number of molecules in a drop of water is
(a) 6.023×10^{23} molecules (b) 1.376×10^{26} molecules
(c) 1.62×10^{21} molecules (d) 4.346×10^{20} molecules

53 In which case is the number of molecules of water maximum? ***NEET 2018***
(a) 0.00224 L of water vapours at 1 atm and 273 K
(b) 0.18 g of water
(c) 18 mL of water
(d) 10^{-3} mol of water

54 For the following reaction, the mass of water produced from 445 g of $C_{57}H_{110}O_6$ is :
$$2C_{57}H_{110}O_6(s) + 163O_2(g) \longrightarrow 114CO_2(g) + 110H_2O(l)$$
(a) 490 g (b) 495 g
(c) 445 g (d) 890 g

55 An oxide of iodine (atomic mass = 127) contains 25.4 g of iodine and 8 g of oxygen. Its formula would be
(a) I_2O_3 (b) I_2O
(c) I_2O_5 (d) I_2O_7

56 How many number of molecules and atoms respectively are present in 2.8 L of a diatomic gas at STP?
(a) $6.023 \times 10^{23}, 7.5 \times 10^{23}$
(b) $6.023 \times 10^{23}, 15 \times 10^{22}$
(c) $7.5 \times 10^{22}, 15 \times 10^{22}$
(d) $15 \times 10^{22}, 7.5 \times 10^{23}$

57 Arrange the following in the order of increasing mass (Atomic mass of O = 16, Cu = 63 and N = 14).
I. One atom of oxygen
II. One atom of nitrogen
III. 1×10^{-10} mole of oxygen
IV. 1×10^{-10} mole of copper
(a) II< I< III< IV (b) I< II< III< IV
(c) III< II< IV< I (d) IV< II< III< I

58 An organic compound on analysis was found to contain 10.06% carbon, 0.84% hydrogen and 89.10% chlorine. What will be the empirical formula of the substance?
(a) CH_2Cl_2 (b) $CHCl_3$ (c) CCl_4 (d) CH_3Cl

59 Find empirical formula of the compound if $M = 68\%$ (atomic mass $= 34$) and remaining 32 % oxygen. ***AIIMS 2019***
(a) MO (b) M_2O
(c) MO_2 (d) M_2O_3

60 A compound contains 69.5% oxygen, 30.5% nitrogen and its molecular weight is 92. The formula of compound is
(a) N_2O (b) NO_2 (c) N_2O_4 (d) N_2O_5

61 An organic compound has an empirical formula (CH_2O). Its vapour density is 45. The molecular formula of the compound is
(a) CH_2O (b) C_2H_5O (c) C_2H_2O (d) $C_3H_6O_3$

62 An organic compound containing C, H and O has 49.3% carbon, 6.84% hydrogen and its vapour density is 73. Molecular formula of the compound is
(a) $C_3H_5O_2$ (b) $C_4H_{10}O_2$ (c) $C_6H_{10}O_4$ (d) $C_3H_{10}O_2$

63 0.0833 mole of carbohydrate of empirical formula CH_2O contain 1 g of hydrogen. The molecular formula of the carbohydrate is
(a) $C_5H_{10}O_5$ (b) $C_3H_4O_3$
(c) $C_{12}H_{22}O_{11}$ (d) $C_6H_{12}O_6$

64 Total number of atoms represented by the compound $CuSO_4 \cdot 5H_2O$ is
(a) 27 (b) 21 (c) 5 (d) 8

65 In a compound, C, H and N are present in the ratio of $9:1:3.5$ by weight. If molecular weight of the compound is 108, then the molecular formula of the compound is
(a) $C_2H_6N_2$ (b) $C_3H_4N_2$ (c) $C_6H_8N_2$ (d) $C_9H_{12}N_3$

66 A compound contains 54.55% carbon, 9.09% hydrogen and 36.36% oxygen .The empirical formula of this compound is
(a) C_3H_5O (b) $C_4H_8O_2$ (c) $C_2H_4O_2$ (d) C_2H_4O

67 The equivalent weight of an element is 4. Its chloride has a vapour density 59.25. Then the valency of the element is
(a) 4 (b) 3 (c) 2 (d) 1

68 In an experiment, 4 g of M_2O_x oxide was reduced to 2.8 g of the metal. If the atomic mass of the metal is 56 g mol^{-1}, the number of O-atoms in the oxide is
(a) 1 (b) 2 (c) 3 (d) 4

69 A gas is found to have the formula $(CO)_x$. Its vapour density is 70. The value of x will be
(a) 7 (b) 4 (c) 5 (d) 6

TOPIC 6 ~ *Stoichiometry and Stoichiometric Calculations*

70 Stoichiometric ratio of sodium dihydrogen orthophosphate and sodium hydrogen orthophosphate required for the synthesis of $Na_5P_3O_{11}$ is
(a) 1.5 : 3 (b) 3 : 1.5 (c) 1 : 1 (d) 2 : 3

71 In the reaction of oxalate with permanganate in acidic medium, the number of electrons involved in producing one molecule of CO_2 is ***JEE Main 2019***
(a) 2 (b) 5 (c) 1 (d) 10

72 2.76 g of silver carbonate on being strongly heated yield a residue of weighing
(a) 2.16 g (b) 2.48 g (c) 2.64 g (d) 2.32 g

73 The decomposition of a certain mass of $KHCO_3$ gave 11.2 dm^3 of CO_2 gas at STP. The mass of KOH required to completely neutralise the gas is
(a) 56 g (b) 28 g
(c) 42 g (d) 20 g

74 x g of Ag was dissolved in HNO_3 and the solution was treated with excess of NaCl, when 2.87g 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

75 Which of the following equations is unbalanced?

(a) $4Fe(s) + 3O_2(g) \longrightarrow 2Fe_2O_3(s)$

(b) $2Mg(s) + O_2(g) \longrightarrow 2MgO(s)$

(c) $P_4(s) + O_2(g) \longrightarrow P_4O_{10}(s)$

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

76 $CH_4(g) + 2O_2(g) \longrightarrow CO_2(g) + 2H_2O(g)$

According to the above chemical reaction, following information have been given.

(i) One mole of $CH_4(g)$ reacts with two moles of $O_2(g)$ to give one mole of $CO_2(g)$ and two moles of $H_2O(g)$

(ii) One molecule of $CH_4(g)$ reacts with 2 molecules of $O_2(g)$ to give one molecule of $CO_2(g)$ and 2 molecules of $H_2O(g)$

(iii) 22.7 L of $CH_4(g)$ reacts with 45.4 L of O_2 to give 22.7 L of $CO_2(g)$ and 45.4 L of $H_2O(g)$

(iv) 16 g of $CH_4(g)$ reacts with 2×32 g of $O_2(g)$ to give 44 g of $CO_2(g)$ and 2×18 g of $H_2O(g)$

From these information the correct interconversion should be

(a) mass $\longrightarrow$ moles $\longrightarrow$ number of molecules.

(b) mass $\rightleftharpoons$ moles $\rightleftharpoons$ number of molecules.

(c) mass $\longrightarrow$ moles $\rightleftharpoons$ number of molecules

(d) mass = moles = number of molecules.

77 1 g of a carbonate (M_2CO_3) on treatment with excess HCl produces 0.01186 mole of CO_2. The molar mass of M_2CO_3 in g mol^{-1} is ***JEE Main 2017***

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

78 When zinc reacts with dilute nitric acid, nitrous oxide is produced. What mass of the gas is evolved by treating 325 g zinc with excess of nitric acid?

(a) 44 g (b) 66 g (c) 55 g (d) 33 g

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

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

80 The number of moles of hydrogen molecules required to produce 20 moles of ammonia through Haber's process is ***NEET 2019***

(a) 20 (b) 30 (c) 40 (d) 10

81 6.02×10^{20} molecules of urea are present in 100 mL of its solution. The concentration of solution is

(a) 0.02 mol L^{-1} (b) 0.01 mol L^{-1}
(c) 0.001 mol L^{-1} (d) 0.1 mol L^{-1}

82 Mole fraction of the solute in a 1.00 molar aqueous solution is ***CBSE AIPMT 2011***

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

83 What will be the molarity of pure water?

(a) 18 M (b) 50.0 M (c) 55.6 M (d) 100 M

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

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

85 What volume of water is to be added to 100 cm^3 of 0.5 M NaOH solution to make it 0.1 M solution?

(a) 200 cm^3 (b) 400 cm^3 (c) 500 cm^3 (d) 100 cm^3

86 Dissolving 120 g of urea (mol. wt. 60) in 1000 g of water gave a solution of density 1.15 g/mL. The molarity of the solution is ***CBSE AIPMT 2011***

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

87 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 ***JEE Main 2019***

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

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

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

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

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

90 A mixture of $CaCl_2$ and NaCl weighing 4.44 g is treated with sodium carbonate solution to precipitate all the Ca^{2+} ions as calcium carbonate. The calcium carbonate so obtained is heated strongly to get 0.56 g of CaO. The percentage of NaCl in the mixture is (Atomic mass of Ca = 40)

(a) 75 (b) 30.6 (c) 25 (d) 69.4

91 In the reaction,

$$2Al(s) + 6HCl(aq) \rightarrow 2Al^{3+}(aq) + 6Cl^-(aq) + 3H_2(g)$$

(a) 6 L $HCl(aq)$ is consumed for every 3L $H_2(g)$ produced

(b) 33.6 L $H_2(g)$ is produced regardless of temperature and pressure for every mole Al that reacts

(c) 67.2 L $H_2(g)$ at STP is produced for every mole Al that reacts

(d) 11.2 L $H_2(g)$ at STP is produced for every mole $HCl(aq)$ consumed

92 Air contains 20% O_2 by volume. How much volume of air will be required for combustion of 100 cc of acetylene?

(a) 500 cc (b) 1064 cc
(c) 212.8 cc (d) 1250 cc

93 $KMnO_4$ reacts with oxalic acid according to the equation,

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

Here, 20 mL of 0.1 M $KMnO_4$ is equivalent to

(a) 20 mL of 0.5 M $H_2C_2O_4$
(b) 50 mL of 0.1 M $H_2C_2O_4$
(c) 50 mL of 0.01 M $H_2C_2O_4$
(d) 20 mL of 0.1 M $H_2C_2O_4$

94 3 g of activated charcoal was added to 50 mL of acetic acid solution (0.06 N) in a flask. After an hour it was filtered and the strength of the filtrate was found to be 0.042 N. The amount of acetic acid adsorbed (per gram of charcoal) is

(a) 18 mg (b) 36 mg (c) 42 mg (d) 54 mg

95 The weight of iron which will be converted into its oxide (Fe_3O_4) by the action of 18 g of steam on it will be

(Atomic weight of Fe = 56)

(a) 168 g (b) 84 g
(c) 42 g (d) 21 g

96 For a reaction,

$N_2(g) + 3H_2(g) \longrightarrow 2NH_3(g)$, identify dihydrogen ($H_2$) as a limiting reagent in the following reaction mixtures. ***JEE Main 2019***

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

SPECIAL TYPES QUESTIONS

I. Statement Based Questions

97 Which of the following statement is true about the science of atoms and molecules?

(a) We can see, weigh and perceive the atoms and molecules through naked eye
(b) It is possible to count the number of atoms and molecules in a given mass of matter through naked eyes manually
(c) We can establish a quantitative relationship between the mass and number of particles
(d) Physical properties of matter cannot be qualitatively described using numerical values with suitable units

98 Which of the following statement is incorrect?

(a) In some elements, the constituents particles are molecules.
(b) The properties such as composition, combustibility, reactivity with acids and bases are chemical properties of matter.
(c) Physical and chemical properties can be measured by changing the identity or composition of substance.
(d) The SI system has seven base units.

99 Choose the incorrect statement from the following.

(a) The SI unit of density is kg m^{-3}
(b) The SI unit of Planck's constant is g^{-1} s^{-1}
(c) The observed SI unit of acceleration is ms^{-2}
(d) The SI unit of velocity is ms^{-1}

100 Which of the following statement is incorrect?

(a) The weight of a substance can be determined very accurately by using an analytical balance.
(b) Volume is denoted in dm^3 units.
(c) Density of a substance is its amount of mass per unit volume.
(d) Candela is the luminous intensity, that emits monochromatic radiation of frequency, 540×10^{12} Hz.

101 Which of the following statement is correct regarding significant figures?

(a) All non-zero digits are significant
(b) Significant figures are meaningful digits which are known with certainty
(c) Zeroes between two non-zero digits are significant
(d) All of the above

102 Which of the following statements is/are correct?

(a) Every experimental measurement has zero amount of uncertainty associated with it
(b) Particles are held very close to each other in solids in a orderly fashion
(c) Pure substances have different characteristics from mixtures
(d) Both (b) and (c)

103 Which of the following rules regarding the significant figures and their calculations is incorrect?

(a) The result of an addition or substraction is reported to the same number of decimal places as present in number with least decimal places
(b) Result of multiplication or division should have same number of significant figures as present in most precise figure
(c) The result of multiplication or division should be rounded off to same number of significant figures as present in least precise figure
(d) The non-significant figures in the measurements are rounded-off

104 Choose the correct statement from the following.
(a) 'amu' has been replaced by unified mass 'u'
(b) Mass of H-atom in terms of amu is 1.0080 amu
(c) Mass of an atom is very big in magnitude
(d) Both (a) and (b)

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

106 Which of the following statement is incorrect?
(a) One atomic mass unit is a mass exactly aqual to one-twelfth the mass of one carbon-12 atom
(b) 'amu' has been replaced by 'u' which is known as unit mass
(c) The formula such as NaCl is used to calculate the molecular mass
(d) Both (b) and (c)

107 Among the following statements, that which was not proposed by Dalton was ***JEE Main 2020***
(a) chemical reactions involve reorganisation of atoms. These are neither created nor destroyed in a chemical reaction.
(b) when gases combine or reproduced in a chemical reaction they do so in a simple ratio by volume provided all gases are at the same T and P.
(c) all the atoms of a given element have identical properties including identical mass. Atoms of different elements differ in mass.
(d) matter consists of indivisible atoms.

108 Consider the following statements :
I. The atoms of different elements are present in a compound in a fixed and definite ratio.
II. In compounds like NaCl, the positive and negative entities are arranged in two dimensional structure.
III. In NaCl, one Na^+ ion is surrounded by 12 Cl^- ions and *vice-versa*.

Choose the option with all the incorrect statements :
(a) I and II (b) II and III (c) Only III (d) I, II and III

II. Assertion and Reason

■ **Directions** (Q. Nos. 109-115) *In the following questions, an Assertion* (A) *is followed by a corresponding Reason* (R). *Use the following keys to choose the appropriate answer.*
(a) Both A and R are correct; R is the correct explanation of A.
(b) Both A and R are correct; R is not the correct explanation of A.
(c) A is correct; R is incorrect.
(d) A is incorrect; R is correct.

109 **Assertion** (A) Synthesise of new materials leads to the production of superconducting ceramics, conducting polymers, optical fibres, etc.

Reason (R) With a better understanding of chemical principle it has now become possible to design and synthesise new materials having specific magnetic, electric and optical properties.

110 **Assertion** (A) Hydrogen burns with a pop sound and oxygen is a supporter of combustion but water is used as a fire extinguisher.

Reason (R) The properties of a compound are different from those of its constituent elements.

111 **Assertion** (A) Significant figures for 0.200 is 3, whereas for 200 it is 1.

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

112 **Assertion** (A) Matter consists of divisible molecules.

Reason (R) Atoms of different elements differ in mass.

113 **Assertion** (A) Carbon-12 is one of the isotope of carbon and can be represented as ^{12}C.

Reason (R) The present system is based on carbon-12 system, ^{12}C is assigned a mass of exactly 12 atomic mass unit (amu) and masses of all other atoms are given relative to this standard.

114 **Assertion** (A) Molality of a solution does not change with temperature.

Reason (R) Mass is affected with temperature.

115 **Assertion** (A) Equivalent weight of ozone in the change $O_3 \longrightarrow O_2$ is 8.

Reason (R) 1 mole of O_3 on decomposition gives 3/2 moles of O_2.

III. Matching Type Questions

116 If we write a result as 11.2 mL then match the items of Column I with Column II and choose the correct option from the codes given below.

Column I (Indication of uncertainty)		Column II (Number associated with uncertainty)	
A.	Certain digit is	1.	2
B.	The uncertain digit is	2.	± 1
C.	The uncertainty in the last digit would be	3.	11

Codes

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

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

Column I	Column II
A. Mass of H_2 produced when 0.5 mole of zinc reacts with excess of HCl.	1. 3.01×10^{23} molecules
B. Mass of all atoms of a compound with formula $C_{70}H_{22}$.	2. 6.023×10^{23} molecules
C. Number of molecules in 35.5 g of Cl_2.	3. 1.43×10^{-21} g
D. Number of molecules in 64 g of SO_2.	4. 1g

Codes

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

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

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

Codes

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

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

Column I	Column II
A. 10 g $CaCO_3 \xrightarrow[\text{Decomposition}]{\Delta}$	1. 0.224 L CO_2
B. 1.06 g $Na_2CO_3 \xrightarrow{\text{Excess HCl}}$	2. 4.48 L CO_2
C. 2.4 g C $\xrightarrow[\text{combustion}]{\text{Excess } O_2}$	3. 0.448 L CO_2
D. 0.56 g CO $\xrightarrow[\text{combustion}]{\text{Excess } O_2}$	4. 2.24 L CO_2
	5. 22.4 L CO_2

Codes

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

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

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

Codes

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

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

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

Codes

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

NCERT & NCERT Exemplar

MULTIPLE CHOICE QUESTIONS

NCERT

122 What will be the mass of one ^{12}C atom in gram?
(a) 2.227×10^{-23} g (b) 1.9927×10^{-23} g
(c) 2.227×10^{-20} g (d) 1.9927×10^{-19} g

123 Which of the following statements is correct about the reaction given below?

$$4Fe(s)+3O_2(g) \longrightarrow 2Fe_2O_3(g)$$

(a) Total mass of iron and oxygen in reactants = Total mass of iron and oxygen in product, therefore it follows law of conservation of mass
(b) Total mass of reactants = Total mass of product, therefore law of multiple proportions is followed
(c) Amount of Fe_2O_3 can be increased by taking anyone of the reactants (iron or oxygen) in excess
(d) Amount of Fe_2O_3 produced will decrease if the amount of any one of the reactants (iron or oxygen) is taken in excess

NCERT Exemplar

124 45.4 L of dinitrogen reacted with 22.7 L of dioxygen and 45.4 L of nitrous oxide was formed. The reaction is given below.

$$2N_2(g)+O_2(g) \longrightarrow 2N_2O(g)$$

Which law is being obeyed in this experiment?
(a) Law of conservation of mass
(b) Law of definite proportion
(c) Law of multiple proportion
(d) Gay Lussac's law of gaseous volumes

125 The mass per cent of different elements present in sodium sulphate, (Na_2SO_4) respectively are
(a) 32.37 ; 45.06 and 22.57 (b) 22.57 ; 32.37 and 45.06
(c) 45.06 ; 32.37 and 40.06 (d) 32.37 ; 22.57 and 45.06

126 How much copper can be obtained from 100 g of copper sulphate ($CuSO_4$)?
(a) 45.79 g Cu (b) 30.50 g Cu
(c) 39.81g Cu (d) 50.10 g Cu

127 What is the concentration of sugar ($C_{12}H_{22}O_{11}$) in mol L^{-1} if its 20 g are dissolved in enough water to make a final volume up to 2 L in mol L^{-1}?
(a) 0.0592 (b) 0.0292 (c) 0.0375 (d) 0.0711

128 Which of the following statements about a compound is/are incorrect?
I. A molecule of a compound has atoms of different elements.
II. A compound cannot be separated into its constituent elements by physical methods of separation.
III. A compound retains the physical properties of its constituent elements.
IV. The ratio of atoms of different elements in a compound is fixed.
(a) Only III (b) Only II (c) I and IV (d) III and IV

129 A measured temperature on Fahrenheit scale is 200°F. What will this reading be on Celsius scale?
(a) 40 °C (b) 94 °C (c) 93.3 °C (d) 30 °C

130 If the density of a solution is 3.12 g mL^{-1}, the mass of 1.5 mL solution in significant figures is ....
(a) 4.7 g (b) 4680×10^{-3} g
(c) 4.680 g (d) 46.80 g

131 Two students performed the same experiment separately and each one of them recorded two readings of mass which are given below. Correct reading of mass is 3.0 g.

Student	Readings	
	I	II
A	3.01	2.99
B	3.05	2.95

On the basis of given data, mark the correct option out of the following statement.
(a) Results of both the students are neither accurate nor precise
(b) Result of student *A* are both precise and accurate
(c) Results of student *B* are precise but not accurate
(d) Results of student *B* are both precise and accurate

132 Which of the following reactions is not correct according to the law of conservation of mass?
(a) $2Mg(s)+O_2(g) \longrightarrow 2MgO(s)$
(b) $C_3H_8(s)+O_2(g) \longrightarrow CO_2(g)+H_2O(g)$
(c) $P_4(s)+5O_2(g) \longrightarrow P_4O_{10}(s)$
(d) $CH_4(g)+2O_2(g) \longrightarrow CO_2(g)+2H_2O(g)$

133 Which of the following statements indicates that, law of multiple proportion is being followed?
(a) Sample of carbon dioxide taken from any source will always have carbon and oxygen in the ratio 1 : 2
(b) Carbon forms two oxides namely CO_2 and CO, where masses of oxygen which combine with fixed mass of carbon are in the simple ratio 2 : 1
(c) When magnesium burns in oxygen, the amount of magnesium taken for the reaction is equal to the amount of magnesium in magnesium oxide formed
(d) At constant temperature and pressure, 200 mL of hydrogen will combine with 100 mL oxygen to produce 200 mL of water vapour

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

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

135 The number of atoms present in one mole of an element is equal to Avogadro's number. Which of the following element contains the greatest number of atoms?

(a) 4 g He (b) 46 g Na (c) 0.40 g Ca (d) 12 g He

136 What is the mass per cent of carbon in carbon dioxide?

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

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

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

138 What will be the molarity of a solution, which contains 5.85 g of NaCl (*s*) per 500 mL?

(a) 4 mol L^{-1} (b) 20 mol L^{-1}
(c) 0.2 mol L^{-1} (d) 2 mol L^{-1}

139 If the concentration of glucose ($C_6H_{12}O_6$) in blood is 0.9 g L^{-1}, what will be the molarity of glucose in blood?

(a) 5 M (b) 50 M
(c) 0.005 M (d) 0.5 M

140 What will be the molality of the solution containing 18.25 g of HCl gas in 500 g of water?

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

141 If 500 mL of a 5 M solution is diluted to 1500 mL, what will be the molarity of the solution obtained?

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

Answers

> Mastering NCERT with MCQs

1 (d)	2 (c)	3 (a)	4 (c)	5 (a)	6 (b)	7 (b)	8 (c)	9 (c)	10 (c)
11 (d)	12 (a)	13 (a)	14 (a)	15 (c)	16 (d)	17 (c)	18 (b)	19 (b)	20 (b)
21 (a)	22 (a)	23 (d)	24 (a)	25 (c)	26 (c)	27 (b)	28 (a)	29 (b)	30 (c)
31 (a)	32 (b)	33 (d)	34 (b)	35 (b)	36 (c)	37 (d)	38 (c)	39 (b)	40 (d)
41 (d)	42 (a)	43 (b)	44 (d)	45 (c)	46 (a)	47 (a)	48 (a)	49 (c)	50 (c)
51 (c)	52 (c)	53 (c)	54 (b)	55 (c)	56 (c)	57 (a)	58 (b)	59 (a)	60 (c)
61 (d)	62 (c)	63 (d)	64 (b)	65 (c)	66 (d)	67 (b)	68 (c)	69 (c)	70 (b)
71 (c)	72 (a)	73 (b)	74 (b)	75 (c)	76 (b)	77 (b)	78 (c)	79 (d)	80 (b)
81 (b)	82 (a)	83 (c)	84 (b)	85 (b)	86 (c)	87 (d)	88 (a)	89 (c)	90 (a)
91 (d)	92 (d)	93 (b)	94 (d)	95 (c)	96 (a)				

> Special Types Questions

97 (c)	98 (c)	99 (b)	100 (a)	101 (d)	102 (d)	103 (b)	104 (d)	105 (d)	106 (d)
107 (d)	108 (b)	109 (a)	110 (a)	111 (c)	112 (d)	113 (b)	114 (c)	115 (a)	116 (a)
117 (c)	118 (b)	119 (a)	120 (a)	121 (a)					

> NCERT & NCERT Exemplar Questions

122 (b)	123 (b)	124 (d)	125 (d)	126 (c)	127 (b)	128 (a)	129 (c)	130 (a)	131 (b)
132 (b)	133 (b)	134 (a)	135 (d)	136 (b)	137 (c)	138 (c)	139 (c)	140 (d)	141 (b)

Hints & Explanations

1 (*d*) Chemistry was not studied for its own sake, rather it came up as a result of search for two interesting things :

(a) 'Philosopher's stone' which would convert all bases metals, e.g. iron and copper into gold.

(b) 'Elexir of life' which would grant immortality.

(c) Paras is the another name of Philosopher's stone.

2 (*c*) The preparation of nitric acid, oxides of Cu, Sn and Zn, Asavas, use of bhasma of metals were described in Charaka Samhita. The preparation of perfumes and cosmetics were described in Brihat Samhita.

3 (*a*) Acharya Kanda, originally known by the name Kashyap was the first proponent of atomic theory.

He named the very small indivisible particles as 'Parmanu' and formulated the atomic theory.

(b) Chakrapani discovered mercury sulphide.

(c) Nagarjuna had discussed methods for the extraction of metals in his book Rasratnakar.

4 (*c*) Taxol and AZT (azidothymidine) are two effective drugs which act as life saving drugs for cancer therapy and AIDS victims, respectively.

6 (*b*) The two types of mixtures are homogeneous mixtures and heterogeneous mixtures. The two types of pure substances are elements and compounds.

Therefore, missing terms are $A \rightarrow$ heterogeneous mixtures, $B \rightarrow$ elements respectively.

8 (*c*) Any quantitative measurement or observation is represented by number followed by units in which it is measured.

Thus, A and B are number and units, respectively.

9 (*c*) $R = 0.0821 \text{ L atm mol}^{-1} \text{ K}^{-1}$

$$= 8.314 \times 10^7 \text{ ergs mol}^{-1} \text{ K}^{-1},$$

[1 K Pa d m^3 = 10^7 erg or 1 J = 10^7 erg

$$= 8.314 \text{ J mol}^{-1} \text{ K}^{-1}$$

$$= 0.002 \text{ kcal mol}^{-1} \text{ K}^{-1} = x \text{ (Assume)}$$

$$\therefore \quad 1 \text{ L atm} = \frac{x}{0.0821} = A$$

$$\Rightarrow \quad 1 \text{ erg} = \frac{x}{8.314 \times 10^7} = B$$

$$1 \text{ J} = \frac{x}{8.314} = C$$

$$\Rightarrow \quad 1 \text{ kcal} = \frac{x}{0.002} = D$$

Thus, $B < C < A < D$

10 (*c*) $$\text{F} = \frac{9}{5} t^\circ \text{C} + 32$$

$$(200 - 32) = \frac{9}{5} t^\circ \text{C}$$

$$\Rightarrow \quad \frac{9}{5} t^\circ \text{C} = 168$$

$$t^\circ \text{C} = \frac{168 \times 5}{9} = 93.3^\circ \text{C}$$

11 (*d*) The correct scientific notation of 0.0034 is 3.4×10^{-3}.

Thus, $0.0034 = 3.4 \times 10^3$ is incorrect.

12 (*a*) 0.00016 can be written as 1.6×10^{-4} in scientific notation.

13 (*a*) The addition of number

$6.65 \times 10^4 + 8.95 \times 10^3$

$$= (6.65 + 0.895) \times 10^4 = 7.545 \times 10^4$$

Also, substraction of numbers

$2.5 \times 10^{-2} - 4.8 \times 10^{-3}$

$$= 2.5 \times 10^{-2} - (0.48 \times 10^{-2})$$

$$= 2.02 \times 10^{-2}$$

The scientific notation will be 7.545×10^4 and 2.02×10^{-2} respectively.

14 (*a*) Avogadro's number is 6.022×10^{23}.

Therefore, four significant figures are present in Avogadro's number.

15 (*c*) Precision refers to the closeness of various measurements for the same quantity. Accuracy is the agreement of a particular value to the true value of the result.

Thus, A and B are precision and accuracy, respectively.

16 (*d*) 9.000 m is the most accurate measurement.

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

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

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

18 (*b*) In addition or subtraction, the result cannot have more digits to the right of the decimal point than either of the original numbers.

$$\begin{array}{r} 12.11 \\ 18.0 \\ 1.012 \\ \hline 31.122 \end{array}$$

Here, 18.0 has only one digit after the decimal point and, therefore the result should be reported only upto one digit after the decimal point which is 31.1.

19 (*b*) In these operations, the result must be reported with not more significant figures as in the measurement with the fewest significant figures.

$$2.5 \times 1.25 = 3.125$$

Since, 2.5 has two significant figures, the result should not have more than two significant figures, thus it is 3.1.

20 (*b*) Density $= \frac{\text{Mass}}{\text{Volume}} = \frac{18.72 \text{ g}}{1.81 \text{ cm}^3}$

$= 10.34 \text{ g/cm}^3$

Therefore, the correct answer is 10.34 g/cm^3 and not 10.3 g/cm^3. Because, the result of multiplication or division should be rounded off to same number of significant figures as present in least precise figure.

21 (*a*) If the rightmost digit to be removed is 5, then the preceding number is not changed, if it is an even number but it is increased by one if it is an odd number. e.g. if 6.35 is to be rounded by removing 5, we have to increase 3 to 4 giving 6.4 as the result. However, if 6.25 is to be rounded off it is rounded off to 6.2.

Thus, *A* and *B* are 6.2 and 6.4, respectively.

22 (*a*) The result of $\frac{0.02856 \times 298.15 \times 0.112}{0.5785}$ has least significant figures.

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

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

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

23 (*d*) The method used to accomplish conversion of units from one system to the other can be termed as factor label method or unit factor method or dimensional analysis.

24 (*a*) $\text{JPa}^{-1} = \frac{\text{J}}{\text{Pa}} = \frac{\text{Work}}{\text{Pressure}} = \frac{\text{N-m}}{\text{N/m}^2} = \text{m}^3$

Thus, unit (JPa^{-1}) is equivalent to m^3.

25 (*c*) The incorrect option is (c). It's correct form is as follows :

$$1 \text{ mg} = 10^{+6} \text{ ng}$$

$$(1 \text{ mg} = 10^{-6} \text{ kg} = 10^{+6} \text{ ng})$$

26 (*c*) Option (c) is incorrect. It's correct form is as follows :

$$1 \text{ m} = 39.37 \text{ inches}$$

27 (*b*) 1.39, 4.33 and 28.1

28 (*a*) Since, $1 \text{ L} = 1000 \text{ cm}^3$ and $1 \text{ m} = 100 \text{ cm}$

$$\frac{1 \text{ m}}{100 \text{ cm}} = 1 = \frac{100 \text{ cm}}{1 \text{ m}}$$

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

Hence, $5 \text{ L} = 5 \times 1000 \text{ cm}^3 \times \frac{1 \text{ m}^3}{10^6 \text{ cm}^3}$

$= \frac{5 \text{ m}^3}{10^3} = 5 \times 10^{-3} \text{ m}^3$

29 (*b*) (i) $28.7 \text{ pm} \times \frac{10^{-12} \text{ m}}{1 \text{ pm}} = 2.87 \times 10^{-11} \text{ m}$

(ii) $15.15 \mu\text{s} \times \frac{10^{-6} \text{ s}}{1 \mu\text{s}} = 1.515 \times 10^{-5} \text{ s}$

(iii) $25365 \text{ mg} \times \frac{1 \text{ g}}{1000 \text{ mg}} \times \frac{1 \text{ kg}}{1000 \text{ g}}$

$= 2.5365 \times 10^{-2} \text{ kg}$

30 (*c*) Average value $= \frac{25.2 + 25.25 + 25.0}{3} = \frac{75.45}{3}$

$= 25.15 = 25.2 \text{ mL}$

Number of significant figures is 3.

31 (*a*) $\underset{4.88 \text{ g}}{2\text{KClO}_3} \longrightarrow \underset{2.96 \text{ g}}{2\text{KCl}} + \underset{1.92 \text{ g}}{3\text{O}_2}$

Since, mass of the products $(2.96 + 1.92)$ is equal to the mass of the reactant, thus result illustrates the law of conservation of mass.

32 (*b*) According to law of conservation of mass,

mass of reactants = mass of products

$\therefore \quad 6.3 + 15.0 = 18.0 + x$

or $\quad x = 21.3 - 18.0$

$= 3.3 \text{ g}$

33 (*d*) Law of definite proportions was given by a French chemist, Joseph Proust. He stated that, a given compound always contains exactly the same proportion of elements by weight.

Thus, irrespective of the source, a given compound always contains same elements in the same proportion.

34 (*b*) To prepare 20 g zinc sulphate crystals,

zinc required $= \frac{22.65}{100} \times 20 = 4.53 \text{ g}$

35 (*b*) CuCl_2, CuSO_4 illustrate the law of multiple proportions. Here, Cu is reacting with two different components to produce two different compounds.

36 (*c*) In *X*O, 50 g of element combines with 50 g of oxygen.

$\therefore$ 1 g of element combines with 1 g of oxygen.

In $X\text{O}_2$, 40 g element combines with 60 g of oxygen.

$\therefore$ 1g of element combines with 1.5 g of oxygen.

Thus, ratio of masses of oxygen which combines with 1 g of element is 1 : 1.5 or 2 : 3. This is in accordance with the law of multiple proportions.

In (b), the law of reciprocal proportions is followed.

In (a), law of conservation of mass is followed while in (d) Avogadro's law is followed.

37 (*d*) According to Avogadro's law, two volumes of hydrogen combine with one volume of oxygen to give two volumes of water without leaving any unreacted oxygen.

38 (*c*) Hydrogen + Oxygen $\longrightarrow$ Water

100 mL 50 mL 100 mL
(*A*)

100 mL of hydrogen combines with 50 mL of oxygen to give 100 mL of water vapour.
Thus, the volumes of hydrogen and oxygen which combine together (i.e. 100 mL and 50 mL) bear a simple ratio of 2 : 1.

39 (*b*) Average atomic weight $= \dfrac{54 \times 5 + 56 \times 90 + 57 \times 5}{100}$

$= 55.95\%$

40 (*d*) Atomic mass of the metal = 64 u

Formula of metal nitrate $= M(NO_3)_2$

$\therefore$ Molecular mass = 64 + 28 + 96 = 188 u

41 (*d*) 100 g alkaloid contains nitrogen = 17.28 g

$\therefore$ 162 g alkaloid will contain nitrogen $= \dfrac{17.28 \times 162}{100}$ g

$= 27.9 \text{ g} \simeq 28 \text{ g}$

Atomic weight of nitrogen = 14

So, number of atoms of nitrogen present in one molecule of alkaloid $= \dfrac{28}{14} = 2$

42 (*a*) Atomic mass of oxygen

$= \dfrac{(99.763 \times 15.995) + (0.037 \times 16.999) + (0.200 \times 17.999)}{100}$

= 15.999 u.

43 (*b*) From the given data in question, the average atomic mass of carbon will come out to be (0.98892) (12 u) + (0.01108) (13.00335 u) + (2×10^{-12}) (14.00317 u)

= 12.011 u

45 (*c*) One mole is the amount of a substance that contains as many particles or entities as there are atoms in exactly 12 g (0.012 kg) of the ^{12}C isotope.

Thus, *X* and *Y* respectively are one mole and ^{12}C.

46 (*a*) The mass of a carbon -12 atom was determined by a mass spectrometer and found to be equal to 1.992648×10^{-23} g.

Thus, *A*, *B* and *C* respectively are 12 atom, mass spectrometer and 1.992648×10^{-23}.

47 (*c*) Hydrocarbon containing C and H upon burning produces CO_2 and water vapour respectively. The equation is represented as

$C_xH_y + (x + y/4)O_2 \longrightarrow xCO_2 + (y/2)H_2O$

Mass of carbon $= \dfrac{12}{44} \times$ mass of CO_2

$= \dfrac{12}{44} \times 88 \text{ g} = 24 \text{ g}$

Mass of hydrogen $= \dfrac{2}{18} \times$ mass of H_2O

$= \dfrac{2}{18} \times 9 = 1 \text{ g}$

So, the unknown hydrocarbon contains 24 g of carbon and 1 g of hydrogen.

48 (*a*) Molar mass of CO_2 = 44 g

44 g of CO_2 = 1 mol of CO_2

22 g of CO_2 = 0.5 mol of CO_2

1 mole of CO_2 contains $= 2 \times 6.023 \times 10^{23}$ O-atoms

$\therefore$ 0.5 mole of $CO_2 = 6.023 \times 10^{23}$ O-atoms

Number of O-atoms in CO $= 6.023 \times 10^{23}$ O-atoms present in 0.5 mole of CO_2 = 1 mole of CO

$\therefore$ Molar mass of 1 mole of CO = 12 + 16 = 28 g

49 (*c*) Mass of $Al_2O_3 = 2 \times 27 + 3 \times 16 = 102$ g

0.051 g of $Al_2O_3 = \dfrac{0.051}{102}$

= 0.0005 mol

$\left(\text{No. of moles} = \dfrac{\text{Mass}}{\text{Molecular mass}}\right)$

1 mole of Al_2O_3 contains $2 \times 6.023 \times 10^{23}$ Al^{3+} ions

0.0005 mole of Al_2O_3 contains

$2 \times 0.0005 \times 6.023 \times 10^{23}$ Al^{3+} ions

$= 6.023 \times 10^{20}$ Al^{3+} ions.

50 (*c*) 12 moles of H-atoms = 1 mole of $(NH_4)_3PO_4$

$\therefore$ 1 mole of H-atom $= \dfrac{1}{12}$ mole of $(NH_4)_3PO_4$

$\therefore$ 6.36 moles of H-atom $= \dfrac{1}{12} \times 6.36$

$= \dfrac{6.36}{12}$ mole of $(NH_4)_3PO_4$

1 mole of $(NH_4)_3PO_4$ = 4 moles of oxygen

So, $\dfrac{6.36}{12}$ mole of $(NH_4)_3PO_4 = \dfrac{4 \times 6.36}{12}$ mole of oxygen

= 2.12 mole of oxygen

51 (*c*) Number of moles of oxygen in the cylinder

$= \dfrac{\text{Mass (in g)}}{\text{Molecular mass (in g mol}^{-1})}$

$$= \frac{2.5\times10^4}{32} = 781.25\,\text{mol}$$

$\therefore$ Number of moles of $N_2 = 3\times781.25 = 2343.75$

Mass of nitrogen in the cylinder $= 2343.75\times28$

$$= 65625\text{ g} = 6.5625\times10^4\text{g}$$

Total mass of the gas in the cylinder

$$= 2.5\times10^4 + 6.5625\times10^4 = 9.0625\times10^4\text{ g}$$

52 (*c*) (i) Density of water = 1 g/mL.

$\therefore$ 1000 mL = 1000 g

(ii) Number of moles of water in 1000 g $(n) = w/m$

$$n = \frac{1000}{18} = 55.56\text{ moles}$$

$\therefore$ Number of moles in 1 mL of water $(n) = \frac{55.56}{1000}$

$$(n) = 0.0556\text{ moles}$$

(iii) $\because$ 1 mL of H_2O contain 20 drops.

$\therefore$ Number of moles of H_2O in one drop $= \frac{0.0556}{20}$

$$(n)\text{ per drop} = 0.0027$$

(iv) $\because\ n = \frac{N}{N_A} = \frac{N}{6.023\times10^{23}}$

$$N = n\times N_A = 0.002\times6.023\times10^{23}$$

$$N = 0.0162\times10^{23} = 1.62\times10^{21}\text{ molecules}$$

53 (*c*) Number of molecules

$$= \text{Mole}\times\text{Avogadro's number }(N_A)$$

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

(a) 0.00224 L of water vapours at 1 atm and 273 K (in L). At STP [1 atm and 273 K],

Number of moles [with reference to volume]

$$= \frac{\text{Volume of gas (in L)}}{22.4}$$

$$= \frac{0.00224}{22.4} = 0.0001\,\text{mol}$$

Number of molecules of water $= 0.0001\times N_A$

(b) 0.18 g of water

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

Number of molecules of water $= 0.01\times N_A$

(c) 18 mL of water

Number of moles

$$(n_{H_2O}) = \frac{\text{Mass of substance in g }(W_{H_2O})}{\text{Molar mass in g mol}^{-1}\ (M_{H_2O})}$$

$W_{H_2O} = 18\text{g}$ [$\because$ Density of water $(d_{H_2O}) = 1\text{g L}^{-1}$]

$\therefore\ n_{H_2O} = 18/18 = 1\,\text{mol}$

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

(d) 10^{-3} mole of water

Number of molecules of water $= 10^{-3}\times N_A$

$\therefore$ Among the given options, option (c) contains the maximum number of water molecules.

54 (*b*) $2C_{57}H_{110}O_6(s) + 163O_2(g) \longrightarrow 110H_2O(l) + 114CO_2(g)$

Molecular mass of $C_{57}H_{110}O_6$

$$= 2\times(12\times57+1\times110+16\times6)\text{ g} = 1780\text{ g}$$

Molecular mass of 110 $H_2O = 110(2+16) = 1980$ g

1780 g of $C_{57}H_{110}O_6$ produced = 1980 g of H_2O

445 g of $C_{57}H_{110}O_6$ produced $= \frac{1980}{1780}\times445$ g of H_2O

$$= 495\text{ g of }H_2O$$

55 (*c*) 25.4 g I_2 combines with 8 g of oxygen.

$\therefore$ 254 g iodine will combine with 80 g of oxygen.

$\therefore$ Formula of oxide of iodine would be I_2O_5.

$$\frac{80}{16} = 5 \text{ and } \frac{254}{2} = 127$$

56 (*c*) Number of molecules of gas at STP

$$= \frac{6.023\times10^{23}\times2.8}{22.4} = 7.5\times10^{22}\text{ molecules}$$

Number of atoms in diatomic molecule $= 2\times7.5\times10^{22}$

$$= 15\times10^{22}\text{ atoms}$$

57 (*a*) I. Mass of one atom of oxygen

$$= \frac{16}{6.022\times10^{23}} = 2.66\times10^{-23}\text{ g}$$

II. Mass of one atom of nitrogen

$$= \frac{14}{6.022\times10^{23}} = 2.32\times10^{-23}\text{ g}$$

III. Mass of 1×10^{-10} mole of oxygen $= 16\times10^{-10}$ g

IV. Mass of 1×10^{-10} mole of copper $= 63\times10^{-10}$ g

Hence, masses of atoms in increasing order :

II < I < III < IV

58 (*b*)

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

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

59 (*a*) Given, % of element $(M) = 68\%$

and of oxygen (O) = 32%

Atomic mass of $M = 34$

Atomic mass of O = 16

Thus, empirical formula of M_xO_y is

element $\longrightarrow$ % of mass $\longrightarrow$ moles (n)

$M \longrightarrow 68 \longrightarrow 68/34 = 2$

$O \longrightarrow 32 \longrightarrow 32/16 = 2$

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

Thus, option (a) is correct.

60 (*c*)

Element	%	% at. wt.	Molar ratio	Ratio
N	30.5	$\frac{30.5}{14} = 2.18$	$\frac{2.18}{2.18} = 1$	1
O	69.5	$\frac{69.5}{16} = 4.34$	$\frac{4.34}{2.18} = 1.99$	2

Empirical formula $= NO_2$

Empirical formula weight = 46

$\therefore \quad n = \frac{92}{46} = 2$

$\Rightarrow$ Molecular formula $= (NO_2)_2 = N_2O_4$

61 (*d*) Molecular weight = 2 × vapour density = 2 × 45 = 90

Empirical formula weight = 12 + 2 + 16 = 30

$\because \quad n = \frac{\text{Mol. wt.}}{\text{Empirical formula wt.}} = \frac{90}{30} = 3$

$\therefore$ Molecular formula of the compound

$= (CH_2O)_3 = C_3H_6O_3$

62 (*c*)

Element	%	Relative number of atom	Simplest ratio
C	49.3	$\frac{49.3}{12} = 4.1$	$\frac{4.1}{2.74} = 1.5 \times 2 = 3$
H	6.84	$\frac{6.84}{1} = 6.84$	$\frac{6.84}{2.74} = 2.5 \times 2 = 5$
O	43.86	$\frac{43.86}{16} = 2.74$	$\frac{2.74}{2.74} = 1 \times 2 = 2$

Thus, the empirical formula is $C_3H_5O_2$.

Empirical formula weight = 3 × 12 + 5 × 1 + 2 × 16

= 36 + 5 + 32 = 73

Molecular weight of the compound = 2 × VD

= 2 × 73 = 146

$$n = \frac{\text{mol. wt.}}{\text{empirical formula wt.}} = \frac{146}{73} = 2$$

Molecular formula = Empirical formula × 2

$= (C_3H_5O_2) \times 2 = C_6H_{10}O_4$

63 (*d*) 0.0833 moles of carbohydrate have hydrogen = 1g

$\therefore$ 1 mole of carbohydrate has hydrogen $= \frac{1}{0.0833} = 12$ g

Given, empirical formula of carbohydrate (CH_2O) has 2 g of hydrogen, $n = 12/2 = 6$

$\therefore$ Molecular formula of carbohydrate is $(CH_2O)_n$

$= (CH_2O) \times 6$

$= C_6H_{12}O_6$.

64 (*b*) Total number of atoms represented by the compound $CuSO_4 \cdot 5H_2O$ is Cu + S + 4O + 10H + 5O = 21.

65 (*c*)

	C	H	N
Ratio	9	1	3.5
Molar ratio	$\frac{9}{12} = 0.75$	$\frac{1}{1} = 1$	$\frac{3.5}{14} = 0.25$
Simpler molar ratio	$\frac{0.75}{0.25} = 3$	$\frac{1}{0.25} = 4$	$\frac{0.25}{0.25} = 1$

So, empirical formula $= C_3H_4N$

Empirical formula weight $= (3 \times 12 + 4 \times 1 + 14) = 54$

$$n = \frac{108}{54} = 2$$

Molecular formula $= (C_3H_4N)_2 = C_6H_8N_2$

66 (*d*)

Element	%	At. weight	% Atomic weight	Simplest molar ratio
C	54.55	12	$\frac{54.55}{12} = 4.54$	$\frac{4.54}{2.27} = 2$
H	9.09	1	$\frac{9.09}{1} = 9.09$	$\frac{9.09}{2.27} = 4$
O	36.36	16	$\frac{36.36}{16} = 2.27$	$\frac{2.27}{2.27} = 1$

$\therefore$ Empirical formula is C_2H_4O.

67 (*b*) Vapour density of chloride = 59.25

Molar mass of chloride = 59.25 × 2 = 118.5

If formula is MCl_n

$M + (n \times 35.5) = 118.5$

$x_n + 35.5n = 118.5$ [as eq. wt $(x_n) = M$]

$4n + 35.5n = 118.5$

$39.5n = 118.5$

$\Rightarrow \quad n = 3$

Formula is MCl_3 or valency of M is 3.

68 (*c*) Mass of oxygen in oxide = 4 − 2.8 = 1.2 g

$$\text{Equivalent weight of metal} = \frac{\text{Mass of metal}}{\text{Mass of oxygen}} \times 8$$

$$= \frac{2.8}{1.2} \times 8 = 18.67$$

$$\text{Valency of metal} = \frac{\text{Atomic weight of metal}}{\text{Eq. weight of metal}}$$

$$= \frac{56}{18.67} = 3$$

$\therefore$ The number of O-atoms in the oxide is 3.

69 (*c*) Vapour density = 70

Molecular mass $= 2 \times 70 = 140$

Formula is $[CO]_x$

Therefore, molecular mass $= (12 + 16)_x = 140$

$= x \times 28 = 140$

$\therefore \quad x = 5$

70 (*b*) $2Na_2HPO_4 + NaH_2PO_4 + 2(NH_2)_2CO \longrightarrow Na_5P_3O_{10} + 4NH_3 + 2CO_2$

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

71 (*c*) Reaction of oxalate with permanganate in acidic medium.

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

n-factor : $(4-3) \times 2 = 2$, $(7-2) = 5$

No. of mol 5, 5, 10

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

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

72 (*a*) $\underset{2 \times 276\text{ g}}{2Ag_2CO_3} \xrightarrow{\Delta} \underset{4 \times 108\text{ g}}{4Ag} + 2CO_2 \uparrow + O_2 \uparrow$

$\because$ 2×276 g of Ag_2CO_3 gives $= 4 \times 108$ g Ag

$\therefore$ 1 g of Ag_2CO_3 gives $= \dfrac{4 \times 108}{2 \times 276}$ g Ag

$\therefore$ 2.76 g of Ag_2CO_3 gives $= \dfrac{4 \times 108 \times 2.76}{2 \times 276}$

$= 2.16$ g Ag

73 (*b*) $\underset{\substack{39+16+1\\=56\text{ g}}}{KOH} + \underset{22.4\text{ dm}^3}{CO_2} \longrightarrow KHCO_3$

$\because$ For 22.4 dm^3 CO_2 required KOH = 56 g

$\therefore$ For 11.2 dm^3 CO_2 will require KOH

$$= \frac{56 \times 11.2}{22.4} = 28 \text{ g}$$

74 (*b*) $2Ag + 2HNO_3 \longrightarrow 2AgNO_3 + H_2 \uparrow$

$2AgNO_3 + 2NaCl \longrightarrow 2AgCl + 2NaNO_3$

$\underset{143.5\text{ g}}{AgCl} \equiv \underset{170\text{ g}}{AgNO_3} \equiv \underset{108\text{ g}}{Ag}$

$\because$ 143.5 g AgCl is obtained from $x = 108$ g

$\therefore$ 2.87 g AgCl is obtained from

$$x = \frac{108 \times 2.87}{143.5} = 2.16 \text{ g}$$

75 (*c*) The unbalanced equation is

$$P_4(s) + O_2(g) \longrightarrow P_4O_{10}(s)$$

It can be balanced as follows :

$$P_4(s) + 5O_2(g) \longrightarrow P_4O_{10}(s)$$

76 (*b*) From the given relationships, the data can be interconverted as,

mass $\rightleftharpoons$ moles $\rightleftharpoons$ number of molecules

77 (*b*) $\underset{1\text{ g}}{M_2CO_3} + 2HCl \longrightarrow 2M\,Cl + H_2O + \underset{0.01186\text{ mole}}{CO_2}$

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

$1/M = 0.01186$ $\quad [M = \text{molar mass of } M_2CO_3]$

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

78 (*c*) $\underset{\substack{4 \times 65\text{ g} = 260\text{ g}\\325\text{ g}}}{4Zn} + 10HNO_3\text{ (dil.)} \longrightarrow 4Zn(NO_3)_2 + \underset{\substack{44\text{ g}\\m}}{N_2O} + 5H_2O$

$\therefore$ The gas evolved by treating 260 g Zn with excess of nitric acid = 44 g

$\therefore$ The gas evolved by treating 325 g of Zn with excess of nitric acid $= (44/260) \times 325 = 55$ g

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

As, 3 moles of $BaCl_2$ required = 2 moles of Na_3PO_4

$\therefore$ 0.5 moles of $BaCl_2$ required $= \dfrac{2}{3} \times 0.5$

$= 0.33$ moles of Na_3PO_4

$\therefore$ Na_3PO_4 is the limiting reagent.

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

$\therefore$ 0.2 mole of $Na_3(PO_4)$ gives $Ba_3(PO_4)_2 = \dfrac{1}{2} \times 0.2$

$= 0.10$ mol

80 (*b*) According to Haber's process,

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

Now, according to above equation

2 moles of ammonia (NH_3) require = 3 moles of H_2

$\therefore$ 1 mole of NH_3 require $= \dfrac{3}{2}$ moles of H_2

or, 20 moles of NH_3 require $= \dfrac{3}{2} \times 20$ moles of H_2

$= 30$ moles of H_2.

81 (*b*) Given, number of molecules of urea $= 6.02 \times 10^{20}$

$\therefore$ Number of moles $= \dfrac{6.02 \times 10^{20}}{N_A}$

$= \dfrac{6.02 \times 10^{20}}{6.023 \times 10^{23}}$

$= 1 \times 10^{-3}$ mol

Volume of the solution = 100 mL $= \dfrac{100}{1000}$ L = 0.1 L

Concentration of urea solution (in mol L^{-1})

$$= \frac{1 \times 10^{-3}}{0.1} \text{ mol L}^{-1} = 1 \times 10^{-2} \text{ mol L}^{-1} = 0.01 \text{ mol L}^{-1}$$

82 (*a*) 1.00 molar aqueous solution

= 1.0 mole in 1000 g water

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

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

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

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

83 (*c*) The molarity of pure water is 55.6 M which can be calculated by $\frac{1000\ (\text{volume in mL})}{18\ (\text{molar mass})} = 55.6\,\text{M}$

84 (*b*) Volume of 100 g sample $= \frac{\text{Mass}}{\text{Density }(d)} = 100/d$

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

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

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

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

85 (*b*) $M_1V_1 = M_2V_2$

$$0.5 \times 100 = 0.1 \times V_2 \Rightarrow V_2 = 500\,\text{cm}^3$$

Volume of water to be added to 100 cm^3 of solution

$$= 500 - 100 = 400\,\text{cm}^3$$

86 (*c*) $\text{Molarity }(M) = \frac{\text{Moles of solute}}{\text{Volume of solution (in L)}}$

Moles of urea = 120/ 60 = 2

Weight of solution = Weight of solvent + Weight of solute

$$= 1000 + 120 = 1120\,\text{g}$$

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

$$\therefore \quad \text{Molarity} = 2 / 0.973 = 2.05\,\text{M}$$

87 (*d*) Mole fraction of solute

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

$$\chi_{\text{Solute}} = \frac{n_{\text{Solute}}}{n_{\text{Solute}} + n_{\text{Solvent}}} = \frac{\frac{w_{\text{Solute}}}{Mw_{\text{Solute}}}}{\frac{w_{\text{Solute}}}{Mw_{\text{Solute}}} + \frac{w_{\text{Solvent}}}{Mw_{\text{Solvent}}}}$$

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

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

$$w_{\text{Solvent}} = w_{H_2O} = 18\,\text{g};$$

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

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

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

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

$$= \frac{\frac{w_{\text{Solute}}}{Mw_{\text{Solute}}}}{w_{\text{Solvent}}\ (\text{in g})} \times 100$$

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

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

88 (*a*) Molarity

$$= \frac{\text{Weight of HNO}_3}{\text{Molecular mass of HNO}_3 \times \text{Volume of solution (in L)}}$$

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

$$= 2 \times 63 \times \frac{250}{1000} = 31.5\,\text{g}$$

It is the weight of 100% HNO_3.

But the given acid is 70% HNO_3

$$\therefore \quad \text{Its weight} = 31.5 \times \frac{100}{70}\,\text{g} = 45.0\,\text{g conc. HNO}_3$$

89 (*c*) Mohr's salt is $[FeSO_4 \cdot (NH_4)_2SO_4 \cdot 6H_2O]$

Only oxidisable part is Fe^{2+}

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

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

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

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

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

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

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

$$= 0.075 \times 294$$

$$= 22.05\ \text{g}$$

90 (*a*) According to question,

$$\underset{1\text{ mol}}{CaCl_2} + Na_2CO_3 + NaCl \longrightarrow \underset{1\text{ mol}}{CaCO_3}$$

$$\underset{1\text{ mol}}{CaCO_3} \xrightarrow{\Delta} \underset{1\text{ mol}}{CaO} + CO_2$$

1 mol of CaO ≅ 1 mol of $CaCl_2$

We know that, number of moles = $\frac{\text{Mass}}{\text{Molecular mass}}$

$$\frac{0.56}{56} \text{ mol of CaO} \cong 0.01 \text{ mol of } CaCl_2$$

$$= 0.01 \times 111 \text{ g } CaCl_2$$
$$= 1.11 \text{ g } CaCl_2$$

Thus, in the mixture, weight of NaCl

$$= 4.44 - 1.11 = 3.33 \text{ g}$$

$\therefore$ Percentage of NaCl = $\frac{3.33}{4.44} \times 100 = 75\%$

91 (*d*) $2Al(s) + 6HCl(aq) \longrightarrow 2Al^{3+}(aq) + 6Cl^-(aq) + 3H_2(g)$

3×22.4 L $H_2(g)$ at STP is produced by 6 moles of HCl (aq).

Hence, 11.2 L $H_2(g)$ at STP is produced by 1 mole of HCl (aq) consumed.

92 (*d*) $\underset{\substack{2\text{ cc}\\100\text{ cc}}}{2C_2H_2} + \underset{\substack{5\text{ cc}\\250\text{ cc}}}{5O_2} \longrightarrow 4CO_2 + 2H_2O$

Hence, air will be needed $= \frac{100}{20} \times 250 = 1250$ cc.

93 (*b*) $2MnO_4^- + 5C_2O_4^{2-} + 16H^+ \longrightarrow 2Mn^{2+} + 10CO_2 + 8H_2O$

20 mL of 0.1 M $KMnO_4 = 20 \times 0.1 = 2$ mmol

$\because$ 2 mmol of $KMnO_4 \equiv 5$ mmol of $C_2O_4^{2-}$

50 mL of 0.1 M $H_2C_2O_4$ or $50 \times 0.1 = 5$ mmol

Hence, 20 mL of 0.1 M $KMnO_4 \equiv 50$ mL of 0.1 M $H_2C_2O_4$

94 (*d*) Given, initial strength of acetic acid = 0.06 N

Final strength = 0.042 N; Volume (given) = 50 mL

$\therefore$ Initial millimoles of $CH_3COOH = 0.06 \times 50 = 3$

Final millimoles of $CH_3COOH = 0.042 \times 50 = 2.1$

$\therefore$ Millimoles of CH_3COOH adsorbed

$= 3 - 2.1 = 0.9$ m mol $= 0.9 \times 60 = 54$ mg

95 (*c*) $\underset{\substack{3\times 56\text{ g}\\=168\text{ g}}}{3Fe} + \underset{\substack{4\times 18\text{ g}\\=72\text{ g}}}{4H_2O} \longrightarrow Fe_3O_4 + 4H_2$

$\because$ 72 g steam required Fe = 168 g

$\therefore$ 18 g steam required Fe $= \frac{168 \times 18}{72} = 42$ g

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

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

28 g N_2 requires 6g H_2 gas.

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

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

Hence, H_2 gas is the limiting reagent.

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

As 28g N_2 required 6g of H_2.

35g N_2 required $\frac{6\text{g}}{28\text{g}} \times 35$ g H_2

$\Rightarrow$ 7.5g of H_2.

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

Mass of H_2 left unreacted = $8 - 7.5$ g of H_2 = 0.5g of H_2

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

For 14g of N_2 + 4g or H_2.

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

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

$\Rightarrow$ 3 g of H_2.

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

97 (*c*) Statement (c) is correct about the science of atoms and molecules, while other given statements are incorrect. Corrected form are as follows :

(a) We cannot see, weigh and perceive the atoms and molecules through naked eye.

(b) It is not possible to count the number of atoms and molecules in a given mass of matter through naked eyes manually.

(d) Physical properties of matter can be quantitatively described using numerical values with suitable units.

98 (*c*) Statement (c) is incorrect.

It's correct form is as follows :

Measurement of physical properties does not require occurrence of any chemical change. These can be measured or observed without changing the identity or the composition of the substance.

While, the measurement of observation of chemical properties requires a chemical change to occur.

Rest other statements are correct.

99 (*b*) Statement (b) is incorrect.

It's correct form is as follows :

The SI unit of Planck's constant is J-s.

Rest other statements are correct.

100 (*a*) Statement (a) is incorrect.

It's correct form is as follows :

The mass of a substance can be determined very accurately by using an analytical balance.

Rest other statements are correct.

102 (*d*) Statements (b) and (c) are correct.

Statement (a) is incorrect.

It's correct form is as follows :

Every experimental measurement has some amount of uncertainty associated with it.

103 (*b*) Statement (b) is incorrect. It's correct form is as follows :

Result of multiplication or division is rounded off to the same number of significant figures as possessed by the least precise term in the calculation.

Rest other statements are correct.

104 (*d*) Statements (a) and (b) are correct, while statement (c) is incorrect.

It's correct form is as follows :

Mass of an atom is very small in magnitude because atoms are extremely small.

106 (*d*) Statements (b) and (c) are incorrect.

It's correct form are as follows :

The formula such as NaCl is used to calculate the formula mass instead of molecular mass as in solid state NaCl does not exist as a single entity.

Also 'u' is abbreviated for unified mass.

107 (*b*) The postulates given in options (a), (c) and (d) are proposed by Dalton.

Option (b) is defining the Gay-Lussac's law of combining volumes of gases.

108 (*b*) Statements II and III are incorrect.

It's correct form are as follows :

II. In such compounds, positive (Na^+ ion) and negative (Cl^- ion) entities are arranged in a three-dimensional structure.

III. In NaCl, one Na^+ ion surrounded by 6 Cl^- ions and *vice-versa*.

Statement I is correct.

111 (*c*) Zeroes at the end or right of a number are significant provided they are on the right side of the decimal point.

As per the above principle, significant figure for 0.200 is 3 while for 200 it is 1.

Thus, A is correct but R is incorrect.

112 (*d*) Matter consists of indivisible atoms.

Thus, A is incorrect but R is correct.

114 (*c*) Molality of a solution does not change with temperature, since mass remains unaffected with temperature.

Thus, A is correct but R is incorrect.

115 (*a*) $2O_3 \longrightarrow 3O_2$ (Balanced equation)

$$2 \text{ moles of } O_3 \equiv 3 \text{ moles of } O_2 = 3 \times 2 \text{ eq. } O_2$$

$$E_{O_3} = M/6 = 48/6 = 8.$$

Thus, both A and R are correct and R is the correct explanation of A.

117 (*c*) The correct match is :

$$A \rightarrow 4, B \rightarrow 3, C \rightarrow 1, D \rightarrow 2$$

A. $Zn + 2HCl \longrightarrow ZnCl_2 + H_2$.

1 mole of Zn produces 2 g of H_2

0.5 mole of Zn will produce 1 g of H_2.

B. $C_{70}H_{22} = 70 \times 12 + 22 \times 1 = 862$

Molar mass = 862

$$\text{Mass of atoms} = \frac{862}{6.023 \times 10^{23}} = 1.43 \times 10^{-21} \text{ g}$$

C. 70 g of $Cl_2 = 6.023 \times 10^{23}$ molecules

35.5 g of $Cl_2 = 3.01 \times 10^{23}$ molecules

D. Molar mass of SO_2 = 64 g = 1 mole

64 g of $SO_2 = 6.023 \times 10^{23}$ molecules.

119 (*a*) The correct match is :

$$A \rightarrow 4, B \rightarrow 1, C \rightarrow 2, D \rightarrow 3$$

A. $$\underset{100\text{ g}}{CaCO_3} \xrightarrow[\text{Decomposition}]{\Delta} CaO + \underset{22.4\text{ L}}{CO_2}$$

$\because$ 100 g $CaCO_3$ on decomposition gives = 22.4 L CO_2

$\therefore$ 10 g $CaCO_3$ on decomposition will give

$$= \frac{22.4 \times 10}{100} \text{ L } CO_2 = 2.24 \text{ L } CO_2$$

B. $$\underset{106\text{ g}}{Na_2CO_3} \xrightarrow{\text{Excess HCl}} 2NaCl + H_2O + \underset{22.4\text{ L}}{CO_2}$$

$\because$ 106 g Na_2CO_3 gives = 22.4 L CO_2

$$\therefore 1.06 \text{ g } Na_2CO_3 \text{ will give} = \frac{22.4 \times 1.06}{106} \text{ L } CO_2$$

$$= 0.224 \text{ L } CO_2$$

C. $$\underset{12\text{ g}}{C} \xrightarrow[\text{Combustion}]{\text{Excess } O_2} \underset{22.4\text{ L}}{CO_2}$$

12 g carbon on combustion gives = 22.4 L CO_2

2.4 g carbon on combustion gives

$$= \frac{22.4 \times 2.4}{12} \text{ L } CO_2$$

$$= 2 \times 2.24 \text{ L } CO_2 = 4.48 \text{ L } CO_2$$

D. $$\underset{\substack{2(12+16)\\56\text{ g}}}{2CO} \xrightarrow[\text{Combustion}]{\text{Excess } O_2} \underset{2 \times 22.4\text{ L}}{2CO_2}$$

56 g carbon monoxide on combustion gives

$$= 2 \times 22.4 \text{ L } CO_2$$

0.56 g carbon monoxide on combustion will give

$$= \frac{2 \times 22.4 \times 0.56}{56} = 0.448 \text{ L } CO_2$$

122 (*b*) $$\text{Mass of 1 atom of } ^{12}C = \frac{\text{Atomic mass of C}}{\text{Avogadro's number}}$$

$$= \frac{12 \text{ g}}{6.022 \times 10^{23}}$$

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

123 (*a*) According to the law of conservation of mass,
Total mass of reactants = Total mass of products.
Amount of Fe_2O_3 is decided by limiting reagent.

124 (*d*) $\underset{2\,V}{2N_2(g)} + \underset{1\,V}{O_2(g)} \longrightarrow \underset{2\,V}{2N_2O(g)}$

$\frac{45.4}{22.7} = 2, \quad \frac{22.7}{22.7} = 1, \quad \frac{45.4}{22.7} = 2$

Hence, the ratio between the volumes of the reactants and the product in the given question is simple, i.e. 2 : 1 : 2, it proves the Gay Lussac's law of gaseous volumes, which states that when gases combine or are produced in a chemical reaction, they do so in a simple ratio by volume provided all gases are at the same temperature and pressure.

125 (*d*) Mass per cent of an element

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

Molar mass of Na_2SO_4

$= (2 \times 22.99) + 32.06 + (4 \times 16.00)$
$= 142.04$ g

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

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

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

126 (*c*) Molar mass of $CuSO_4 = 63.54 + 32.06 + (4 \times 16)$

$= 159.6 \text{ g mol}^{-1}$

159.6 g $CuSO_4$ contain = 63.54 g Cu

1 g $CuSO_4$ contain $= \frac{63.54}{159.6}$ g Cu

$\therefore$ 100 g $CuSO_4$ contain $= \frac{63.54 \times 100}{159.6}$

$= 39.81$ g Cu

127 (*b*) Molar mass of the sugar, $(C_{12}H_{22}O_{11})$

$m = (12 \times 12.01) + (22 \times 1.0079) + (11 \times 16.00)$
$= 342.2938 \text{ g mol}^{-1}$
$\approx 342 \text{ g mol}^{-1}$

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

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

$$= \frac{20}{342 \times 2}$$

$= 0.0292 \text{ mol L}^{-1}$
$= 0.0292$ M

128 (*a*) Statement III is incorrect. It's correct form is as follows :

A compound do not retains the physical properties of its constituent elements. It usually retains the chemical properties of its constituent atoms.

Rest other statements are correct.

129 (*c*) We know that : $°F = \frac{9}{5} t° C + 32$

Putting the values in above equation, $200 - 32 = \frac{9}{5} t° C$

$\Rightarrow \quad \frac{9}{5} t° C = 168$

$\Rightarrow \quad t° C = \frac{168 \times 5}{9} = 93.3° C$

130 (*a*) Given that,

Density of solution $= 3.12 \text{ g mL}^{-1}$

Volume of solution = 1.5 mL

For a solution, Mass = Volume × Density

$= 1.5 \text{ mL} \times 3.12 \text{ g mL}^{-1} = 4.68$ g

The digit 1.5 has only two significant figures, so the answer must also be limited to two significant figures. So, it is rounded off to reduce the number of significant figures.

Hence, the answer is reported as 4.7 g.

131 (*b*) Average readings of student, $A = \frac{3.01 + 2.99}{2} = 3.00$

Average readings of student, $B = \frac{3.05 + 2.95}{2} = 3.00$

Correct reading = 3.00

For both the students, average value is close to the correct value. Hence, readings of both precise and accurate.

Readings of student *A* are close to each other (differ only by 0.02) and also close to the correct reading, hence readings of *A* are precise also. But readings of *B* are not close to each other (differ by 0.1) and, hence are not precise.

132 (*b*) $C_3H_8(g) + O_2(g) \longrightarrow CO_2(g) + H_2O(g)$

This reaction is not correct according to the law of conservation of mass, because it is not the balanced chemical equation.

133 (*b*) The element, carbon, combines with oxygen to form two compounds, namely, carbon dioxide and carbon monoxide. In CO_2, 12 parts by mass of carbon combine with 32 parts by mass of oxygen, while in CO, 12 parts by mass of carbon combine with 16 parts by mass of oxygen.

Therefore, the masses of oxygen combine with a fixed mass of carbon (12 parts) in CO_2 and CO are 32 and 16 respectively. These masses of oxygen bear a simple ratio of 32 : 16 or 2 : 1 to each other.
This is an example of law of multiple proportion.

134 (*a*) One mole of any substance contains 6.022×10^{23} atoms/ molecules. Hence, number of millimoles of H_2SO_4

$$= \text{Molarity} \times \text{Volume (in mL)}$$
$$= 0.02 \times 100 = 2 \times 10^{-3} \text{ mol}$$

$$\text{Number of molecules} = \text{number of moles} \times N_A$$
$$= 2 \times 10^{-3} \times 6.022 \times 10^{23}$$
$$= 12.044 \times 10^{20} \text{ molecules}$$

135 (*d*) 12 g of He (3 moles of He) contains the greatest number of atoms.

$$4 \text{ g of He} = 6.023 \times 10^{23} \text{ atoms of He}$$
$$12 \text{ g of He contains } = \frac{6.023 \times 10^{23}}{4} \times 12$$
$$= 18.069 \times 10^{23} \text{ atoms of He.}$$

136 (*b*) Molecular mass of $CO_2 = 1 \times 12 + 2 \times 16 = 44$ g

1 g molecule of CO_2 contains 1 g atoms of carbon

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

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

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

137 (*c*) Empirical formula mass = CH_2O

$$= 12 + 2 \times 1 + 16 = 30$$
$$\text{Molecular mass} = 180$$
$$n = \frac{\text{Molecular mass}}{\text{Empirical formula mass}}$$
$$= 180/30 = 6$$
$$\therefore \quad \text{Molecular formula} = n \times \text{empirical formula}$$
$$= 6 \times CH_2O = C_6H_{12}O_6$$

138 (*c*) 1 mole of NaCl contains = 58.5 g

$$\text{Molarity of a solution} = \frac{\frac{5.85}{58.5} \text{ mol}}{\frac{500}{1000} \text{ L}}$$
$$= \frac{0.1 \text{ mol}}{1/2 \text{ L}} = 0.2 \text{ mol/L}$$

139 (*c*) 1 mole of glucose

$$(C_6H_{12}O_6) = 12 \times 6 + 12 \times 1 + 6 \times 16$$
$$= 72 + 12 + 96 = 180 \text{ g}$$
$$\text{Molarity of glucose} = \frac{0.9}{180} \text{ mol/L} = 0.005 \text{ M}$$

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

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

Given that, Mass of solvent $(H_2O) = 500 \text{ g} = 0.5 \text{ kg}$

Weight of HCl = 18.25 g

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

$$\text{Moles of HCl} = \frac{18.25}{36.5} = 0.5$$
$$m = \frac{0.5}{0.5} = 1 \text{ m} \quad \text{[from eq. (i)]}$$

141 (*b*)

$$M_1V_1 = M_2V_2$$
$$5 \times 500 = M_2 \times 1500$$
$$\frac{5 \times 500}{1500} = M_2$$
$$M_2 = 1.66 \text{ M}$$