

Some Basic Concepts in Chemistry



Physical Quantities and their Measurements

Mass, length, time and temperature are physical quantities. These are expressed in numerals with suitable units. Units may be basic (fundamental) or derived.

The units of mass (kg), length (m), time (s), electric current (A), temperature (K), luminous intensity (cd), and amount of substance (mol) are fundamental units.

Derived units are basically derived from the fundamental units. *e.g.*, unit of density (kg m^{-3}) is derived from units of mass (kg) and volume (m^{-3}).

Precision and Accuracy

The term **precision** refers for the closeness of the set of values obtained from identical measurements of a quantity. Precision is simply a measure of reproducibility of an experiment.

Accuracy, a related term, refers to the closeness of a single measurement to its true value.

Significant Figures

A significant figure includes all those digits that are known with certainty plus one more which is uncertain.

Rules for Reporting Significant Figures

Read the number from left to right and count all the digits, starting with the first digit that is not zero.

When adding or subtracting, the number of decimal places in the answer should not exceed the number of decimal places in either of the numbers. *e.g.*, $4.1 + 6.21 + 7.008 = 17.318$ is reported as 17.3.

In multiplication and division, the result should be reported to the same number of significant figures as that in the quantity with least number of significant figures. *e.g.*, $132.07 \times 0.12 = 15.8484$ is reported as 15 because 0.12 has only two significant figures.

When a number is rounded off, the number of significant figures is reduced. The last digit retained is increased by 1 only if the following digit is ≥ 5 and is left as such if the following digit is ≤ 4 . *e.g.*, 18.35 can be written as 18.4 and 13.93 can be written as 13.9.

Day 1 *Outlines*

- Physical Quantities and Their Measurements
- Precision and Accuracy
- Significant Figures
- SI Units
- Matter
- Laws of Chemical Combination
- Dalton's Atomic Theory
- Atomic and Molecular Masses
- Mole Concept
- Chemical Equations and Stoichiometry
- Avogadro's Hypothesis
- Equivalent Weight
- Percentage Composition Empirical and Molecular Formulae

SI Units

In October 1960, the General conference of Weights and Measures adopted a particular choice now known as the International System of Units popularly known as SI units.

The SI has seven base units (See Table given below) from whom all other units are derived.

The Seven Base of Units

Physical Quantity	Unit	Unit Symbol
Length	metre	m
Mass	kilogram	kg
Time	second	s
Temperature	kelvin	K
Amount of substance	mole	mol
Electric current	ampere	A
Luminous intensity	candela	cd
Plane angle*	radian	rad
Solid angle*	steradian	sr

*These are two other fundamental quantities with dimensionless units.

A number of quantities must be derived from measured value of the SI base quantities.

These are called derived units. *e.g.*, units of density (kgm^{-3}) is derived from the units of mass and length.

Dimensional Analysis

Many of the calculations of general chemistry simple require that conversion of quantities from one set of units to another. This is done by using Conversion Factor (C.F.), A C.F. must always have the numerator and denominator representing equivalent quantities.

Information sought = Information given \times C.F.

Matter

Anything that occupies space and possesses mass is called matter. On the basis of chemical composition of substance, it is of three types.

- Elements** are the substances that cannot be decomposed into simpler substances by chemical change.
- Compounds** can be decomposed into simpler substances by chemical changes. Compound is always homogeneous.
- Mixtures** have variable composition and variable properties due to the fact that components retain their characteristic properties. Components of a mixture can be separated by applying physical methods.

Laws of Chemical Combination

- Law of conservation of mass** (Lavoisier, 1774)
Total mass of reactants = total mass of products.
- Law of constant composition/definite proportions** (Proust, 1799) For the same compound, obtained by different methods, the percentage of each element should be same in each case.
- Law of multiple proportions** (Dalton, 1804) An element may form more than one compound with another element. For a given mass of an element, the masses of other elements (in two or more compounds) are in the ratio of small integers. For example, in NH_3 and N_2H_4 , fixed mass of nitrogen requires hydrogen in the ratio 3 : 2.
- Law of reciprocal proportions** (Richter, 1794) Weights of two different elements which are combining with a fixed weight of a third element, are also the weights with which they combine with one another or their multiples. *e.g.*, CH_4 , CO_2 and H_2O .
- Law of combining volumes** (Gay-Lussac, 1808) The volume of reactants and products in a large number of chemical reactions of gases are related to each other by small integers, provided the volumes are measured at the same temperature and pressure.

Dalton's Atomic Theory

John Dalton developed his famous theory of atoms in 1803. The main postulates of this theory were :

- Atom was considered as a hard, dense and smallest indivisible particle of matter.
- Atom is indestructible *i.e.*, it cannot be destroyed or created.
- Atom is the smallest portion of matter which takes part in chemical combination.
- Atoms combine with each other, to form **compound** atom or molecule, in simple whole number ratio.

Atomic Mass

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

Since most of the elements have isotopes, so their actual atomic mass in the average of atomic masses of all the isotopes and hence generally in fraction.

Average atomic mass is calculated as

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

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

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

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

This is called **Dulong and Petit's method**.

Mass spectrometer is used to determine the atomic mass experimentally.

Molar Mass

Molar mass of an element is defined as mass of 1 mole of that element, *i.e.*, mass of 6.023×10^{23} entities or particles of that element, *e.g.*, molar mass of oxygen = 32 g/mol, that means 6.023×10^{23} molecules of oxygen weigh 32 g.

Mole Concept

Mole is the amount of substance which contains Avogadro's number ($N_A = 6.022 \times 10^{23}$) of particles and has mass equal to gram-atomic mass or gram-molecular mass.

$$\text{Mol} = \frac{\text{mass (g)}}{\text{molar mass (g mol}^{-1}\text{)}}$$

1 mol atoms = gram-atomic weight = 1 gram atom of element = 6.022×10^{23} atoms.

1 mol molecules = gram-molecular weight = 1 gram mole of substance = 6.022×10^{23} molecules.

In gaseous state (at STP), $T = 273 \text{ K}$, $p = 1 \text{ atm}$

$$\begin{aligned} \text{Gram molecular wt.} &= 1 \text{ mol} = 22.4 \text{ L} \\ &= 6.022 \times 10^{23} \text{ molecules} \end{aligned}$$

$$1 \text{ amu or u} = \frac{1}{12} \times \text{mass of one carbon (C}^{12}\text{) atom}$$

$$1 \text{ u} = \frac{1}{6.022 \times 10^{23}} \text{ g} = 1.66 \times 10^{-24} \text{ g}$$

Atomic mass in u = wt. of one atom

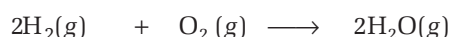
Molecular mass in u = wt. of one molecule

e.g., $\text{He}^4 \quad 4\text{u} = 1 \text{ atom of He}$

$\text{H}_2\text{O} \quad 18\text{u} = 1 \text{ molecule of H}_2\text{O}$
(mol wt. = 18)

Chemical Equations and Stoichiometry

A balanced chemical equation with suitable stoichiometric coefficients represents the ratio of number of moles of reactants and products. The equation provides qualitative and quantitative information about a chemical change in a simple manner. For example



Mole ratio	2 mol	1 mol	2 mol
Molecule ratio	$2 \times 6.022 \times 10^{23}$ molecules	6.022×10^{23} molecules	$2 \times 6.022 \times 10^{23}$ molecules
Weight ratio	4g	32g	36g
Volume ratio	2 volume	1 volume	2 volume

(Volume ratio is valid for gaseous state at same temperature and pressure.)

Limiting Reagent

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

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

Avogadro's Hypothesis

Equal volumes of gases or vapours obeying gas laws under similar conditions of pressure and temperature contain equal number of molecules.

Molecular weight (for gaseous phase only)

$$= 2 \times \text{vapour density}$$

Equivalent Weight

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

$$\text{Equivalent wt. (Eq. wt.)} = \frac{\text{atomic wt. or molecular wt.}}{\text{'n' factor}}$$

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

(i) 'n' Factor for Acids *i.e.*, Basicity

Number of ionisable H^+ per molecule is the basicity of acid. *e.g.*,

- Basicity of $\text{HCl} = 1$
- Basicity of $\text{H}_2\text{SO}_4 = 2$
- Basicity of $\text{H}_3\text{PO}_4 = 3$

(ii) 'n' Factor for Bases *i.e.*, Acidity

Number of ionisable OH^- per molecule is the acidity of a base. *e.g.*,

- Acidity of $\text{NaOH} = 1$
- Acidity of $\text{Mg}(\text{OH})_2 = 2$
- Acidity of $\text{Al}(\text{OH})_3 = 3$

(iii) 'n' Factor for Salt

Total positive or negative charge of ions.

- $\text{Na}_2\text{CO}_3 \longrightarrow 2\text{Na}^+ + \text{CO}_3^{2-} \quad n = 2$
- $\text{NaHCO}_3 \longrightarrow \text{Na}^+ + \text{HCO}_3^- \quad n = 1$
- $\text{Al}_2(\text{SO}_4)_3 \longrightarrow 2\text{Al}^{3+} + 3\text{SO}_4^{2-} \quad n = 6$

(iv) 'n' Factor for Ion

In case of ion 'n' factor is equal to charge of that ion.

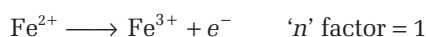
e.g.,

$$E_{\text{Cl}^-} = \frac{35.5}{1} = 35.5; E_{\text{CO}_3^{2-}} = \frac{60}{2} = 30$$

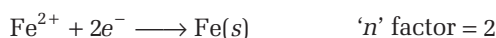
$$E_{\text{Al}^{3+}} = \frac{27}{3} = 9.0$$

(v) 'n' Factor for Redox Titration

(a) $\text{FeSO}_4 \Rightarrow$ As reducing agent

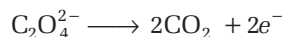


\Rightarrow As an oxidising agent



(b) $\text{H}_2\text{C}_2\text{O}_4$ or $\text{C}_2\text{O}_4^{2-}$

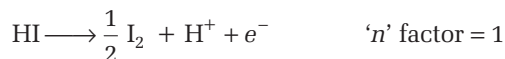
\Rightarrow As reducing agent only



'n' factor = 2

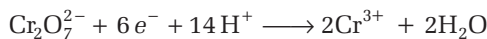
(c) HI

\Rightarrow As reducing agent only



(d) $\text{K}_2\text{Cr}_2\text{O}_7$

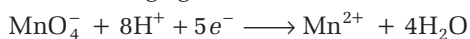
\Rightarrow As oxidising agent only (acidic)



'n' factor = 6

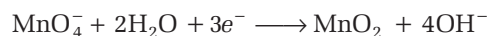
(e) KMnO_4

\Rightarrow As oxidising agent in acidic medium



'n' factor = 5

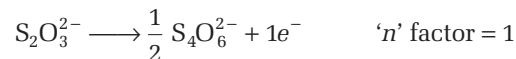
\Rightarrow As oxidising agent in alkaline medium



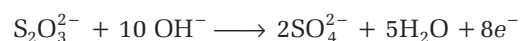
'n' factor = 3

(f) $\text{Na}_2\text{S}_2\text{O}_3$ (sodium thiosulphate)

\Rightarrow As reducing agent in acidic medium



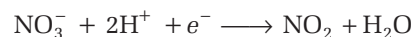
\Rightarrow As reducing agent in alkaline medium



'n' factor = 8

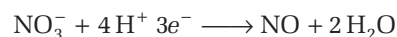
(g) HNO_3 (nitric acid)

\Rightarrow As oxidising agent (conc. HNO_3)



'n' factor = 1

\Rightarrow As oxidising agent (dil HNO_3)



'n' factor = 3

Percentage Composition, Empirical and Molecular Formulae

Mass % of an element

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

Dividing percentage by atomic mass gives molar ratio from which **empirical formula** is obtained.

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

Molecular formula = $n \times$ empirical formula

Molar mass = $2 \times$ vapour density

Additional Points...

- The gram-atomic mass of an element should not be confused with the mass of its atom (actual mass) e.g., gram-atomic mass of hydrogen is 1.008 g but mass of H atom is 1 u, i.e., 1.67×10^{-24} g.
- Approximate atomic mass = $\frac{6.4}{\text{sp. heat (in cal g}^{-1}\text{)}}$ (from Dulong and Petit's law for metals)
Exact atomic mass = Eq. mass \times valency
- Molecular mass = $2 \times$ vapour density or mass of 22.4 L of vapour at STP.
- Equivalent mass of oxidising/reducing agent = $\frac{\text{molecular mass of oxidising / reducing agent}}{\text{no. of electrons gained or lost by one molecule}}$
- Equivalents of reactants react to give same number of equivalents of products whereas moles react according to stoichiometry of equation.



GETTING READY

Exercise

(Target JEE Main)

6. In stoichiometry, if the quantities of two or more reactants are given, the amounts of products formed depend upon the limiting reactant (the reactant which consumed first in the reaction).
- The total number of electrons present in 18 mL of water (density of water is 1 g mL^{-1}) is
(a) 6.02×10^{23} (b) 6.02×10^{23}
(c) 6.02×10^{24} (d) 6.02×10^{25}
 - If 1 mL of water contains 20 drops, what is the number of water molecules in the one drop of water?
(A = Avogadro number)
(a) $\frac{0.5}{18} A$ (b) $0.05 A$
(c) $\frac{0.05}{18} A$ (d) $0.5 A$
 - The number of gram molecules of oxygen in 6.02×10^{24} CO molecules is
(a) 10 g (b) 5 g
(c) 1 g molecules (d) 0.5 g molecules
 - The weight of 1×10^{22} molecules of $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ is
(a) 41.59 g (b) 415.9 g
(c) 4.159 g (d) None of these
 - The sulphate of a metal *M* contains 9.87% of *M*. The sulphate is isomorphous with $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$. The atomic weight of *M* is
(a) 40.3 (b) 36.3 (c) 24.3 (d) 11.3
 - Rearrange the following (I to IV) in the order of increasing masses and choose the correct answer (atomic mass; O = 16, Cu = 63, N = 14,)
I. 1 molecule of oxygen
II. 1 atom of nitrogen
III. 1×10^{-10} g molecular weight of oxygen
IV. 1×10^{-10} g atomic weight of copper
(a) $\text{II} < \text{I} < \text{III} < \text{IV}$ (b) $\text{IV} < \text{III} < \text{II} < \text{I}$
(c) $\text{II} < \text{III} < \text{I} < \text{IV}$ (d) $\text{III} < \text{IV} < \text{I} < \text{II}$
 - One mole of calcium phosphide on reaction with excess of water gives
(a) one mole of phosphine
(b) two moles of phosphoric acid
(c) two moles of phosphine
(d) one mole of phosphorus pentoxide
 - The equivalent weight of H_3PO_2 , when it disproportionates into PH_3 and H_3PO_4 , is
(a) 82 (b) 61.5
(c) 33 (d) 20.5
 - Medical experts generally consider a lead level of $30 \mu\text{g Pb}$ per dL of blood to pose a significant health risk (1 dL = 0.1 L). Express this lead level as the number of Pb atoms per cm^3 blood (Pb = 207).
(a) 8.72×10^{14} (b) 8.72×10^{15}
(c) 8.72×10^{13} (d) 8.72×10^{16}
 - The percentage of water of crystallisation in a sample of blue vitriol is
(a) 34.07% (b) 35.07%
(c) 36.07% (d) 37.07%
 - A 100 mL solution of 0.1 N HCl was titrated with 0.2 N NaOH solution. The titration was discontinued after adding 30 mL of NaOH solution. The remaining titration was completed by adding 0.25 N KOH solution. The volume of KOH required for completing the titration is
(a) 70 mL (b) 32 mL
(c) 35 mL (d) 16 mL
 - How much of NaOH is required to neutralise 1500 cm^3 of 0.1 N HCl? (Na = 23)
(a) 40 g (b) 4 g
(c) 6 g (d) 60 g
 - 10 dm^3 of N_2 gas and 10 dm^3 of gas X at the same temperature contain the same number of molecules. The gas X is
(a) CO (b) CO_2 (c) H_2 (d) NO
 - The volume of water to be added to 100 cm^3 of 0.5 N H_2SO_4 to get decinormal concentration, is
(a) 100 cm^3 (b) 450 cm^3
(c) 500 cm^3 (d) 400 cm^3

15. A metal oxide contains 53% metal and carbon dioxide contains 27% carbon. Assuming the law of reciprocal proportions, the percentage of metal in the metal carbide is
 (a) 75 (b) 25
 (c) 37 (d) 66
16. 30 g of magnesium and 30 g of oxygen are reacted, then the residual mixture contains
 (a) 60 g of magnesium oxide only
 (b) 40 g of magnesium oxide and 20 g of oxygen
 (c) 45 g of oxygen and 15 g of magnesium oxide
 (d) 50 g of magnesium oxide and 10 g of oxygen
17. 5 mL of N HCl, 20 mL of N/2 H₂SO₄ and 30 mL of N/3 HNO₃ are mixed together and volume made to 1 L. The normality of resulting solution is
 (a) 0.45 (b) 0.025
 (c) 0.9 (d) 0.05
18. 3 g of an oxide of a metal is converted to chloride completely and it yielded 5 g of chloride. The equivalent weight of the metal is
 (a) 33.25 (b) 3.325
 (c) 12 (d) 20
19. Assuming that the density of water to be 1 g / cm³, calculate the volume occupied by one molecule of water is
 (a) 2.989×10^{-23} cm³ (b) 6.023×10^{23} cm³
 (c) 22400 mL (d) 18 cm³
20. If 0.5 moles of BaCl₂ are mixed with 0.2 moles of Na₃PO₄, the maximum number of moles of Ba₃(PO₄)₂ that can be formed, is
 (a) 0.7 (b) 0.5
 (c) 0.30 (d) 0.10
21. If 10²¹ molecules are removed from 200 mg of CO₂, the number of moles of CO₂ left are
 (a) 2.88×10^{-3} (b) 28.8×10^{-3}
 (c) 0.288×10^{-3} (d) 1.66×10^{-2}
22. Which of the following pairs of gases contains the same number of molecules?
 (a) 16 g of O₂ and 14 g of N₂
 (b) 8 g of O₂ and 22 g of CO₂
 (c) 28 g of N₂ and 22 g of CO₂
 (d) 32 g of O₂ and 32 g of N₂
23. How many moles of KI are required to produce 0.4 moles of K₂HgI₄?
 (a) 0.4 (b) 0.8
 (c) 3.2 (d) 1.6
24. How much AgCl will be formed by adding 200 mL of 5 N HCl to a solution containing 1.7 g AgNO₃ (Ag = 108)?
 (a) 0.1435 g (b) 1.435 g
 (c) 14.35 g (d) 143.5 g
25. 1.00×10^{-3} moles of Ag⁺ and 1.00×10^{-3} moles of CrO₄²⁻ react together to form solid Ag₂CrO₄. Calculate the amount of Ag₂CrO₄ formed (Ag₂CrO₄ = 331.73 g mol⁻¹).
 (a) 0.268 g (b) 0.166 g
 (c) 0.212 g (d) 1.66 g
26. What would be the weight of the slaked lime required to decompose 8.0 g of ammonium chloride?
 (a) 5.53 g (b) 2.12 g
 (c) 15.52 g (d) 7.62 g
- Directions** (Q. Nos. 27 and 28) *The following is a crude but effective method for estimating the order of magnitude of Avogadro's number using stearic acid (C₁₈H₃₆O₂). When stearic acid is added to water, its molecules collect at the surface and form a monolayer, i.e., the layer is only one molecule thick. The cross sectional area of each stearic acid molecule has been measured to be 0.21 nm². In one experiment it is found that 1.4×10^{-4} g of stearic acid is needed to form a mono layer over water in a dish of diameter 20 cm. (The area of a circle of radius r is πr^2 .)*
27. Based on these measurements value of Avogadro's number is
 (a) 3×10^{23} (b) 6×10^{23}
 (c) 4×10^{23} (d) 1×10^{23}
28. What is the equivalent of 1g H in atomic mass unit for this value of Avogadro's number?
 (a) 1.66×10^{-24} g (b) 3.33×10^{-24} g
 (c) 2.5×10^{-24} g (d) 1×10^{-23} g
- Directions** (Q. Nos. 29 to 31) *One gram of activated charcoal has a surface area of 10³m². One molecule of ammonia having a diameter of 0.3 nm is adsorbed completely on the surface of charcoal (unilayer adsorption). The activated charcoal is brought in contact with 100 mL of 2 M NH₃ solution.*
29. The number of ammonia molecules adsorbed on the charcoal surface is
 (a) 1.4×10^{22} (b) 1.4×10^{21}
 (c) 1.4×10^{23} (d) 1.4×10^{19}
30. The moles of HCl required to neutralise left ammonia solution after adsorption is
 (a) 0.123 (b) 0.145 (c) 0.153 (d) 0.175
31. The volume of HCl(g) at STP required to clean up all ammonia molecules adsorbed on the surface is
 (a) 0.175 L (b) 0.230 L
 (c) 0.480 L (d) 0.526 L
- Directions** (Q. Nos. 32 to 35) *Each of these questions contains two statements : Statement I (Assertion) and statement II (Reason). Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below*
- (a) Statement I is true, Statement II is true; Statement II is a correct explanation of Statement I.

- (b) Statement I is true, Statement II is true; Statement II is not a correct explanation of statement I.
(c) Statement I is true; Statement II is false.
(d) Statement I is false; Statement II is true.
- 32. Statement I** When 10 g of CaCO_3 is decomposed, 5.6 g of residue is left and 4.4 g of CO_2 escapes.
Statement II Law of mass conservation is followed.
- 33. Statement I** In Fe^{2+} , there are 24 electrons and 30 neutrons and thus, ionic mass is 56.
Statement II Ionic mass = neutron + electrons in the neutral species.
- 34. Statement I** On changing volume of the solution by 20%, molarity of solution also changes by 20%.
Statement II Molar concentration or molarity of solution changes on dilution.
- 35. Statement I** H_3BO_3 is monobasic Lewis acid but salt Na_3BO_3 exists.
Statement II H_3BO_3 reacts with NaOH to give Na_3BO_3 .
- 36.** 5 g of Ag_2CO_3 and CaCO_3 on heating gives a residue which required 100 mL of M/5 HCl for complete neutralisation. The percentage of Ag in original mixture will be
(a) 31.3% (b) 62.6%
(c) 67.6% (d) 78.2%
- 37.** The molecular mass of an organic acid was determined by the study of its barium salt. 4.290 g of salt was converted to free acid by the reaction with 21.64 mL of 0.477 M H_2SO_4 . The barium salt was found to have two moles of water of hydration per Ba^{2+} ion and the acid is monobasic. What is the molecular weight of anhydrous acid?
(a) 121.6 (b) 140
(c) 122.6 (d) 330.1
- 38.** A mixture of FeO and Fe_3O_4 when heated in air to constant weight, gains 5% in its weight. What is the percentage of Fe_3O_4 in mixture?
(a) 73.87% (b) 26.13%
(c) 79.75% (d) 20.25%
- 39.** Weight of 1 L milk is 1.032 kg. It contains butter fat (density 865 kg m^{-3}) to the extent of 4% by volume/volume. The density of the fat free skimmed milk will be
(a) 1038.5 kg m^{-3} (b) 1032.2 kg m^{-3}
(c) 997 kg m^{-3} (d) 1000.5 kg m^{-3}
- 40.** Sea water contains $65 \times 10^{-3} \text{ g L}^{-1}$ of bromide ions. If all the bromide ions are converted to produce Br_2 , how much sea water is needed to prepare 1 kg Br_2 ?
(a) 15.38 L (b) $15.38 \times 10^3 \text{ L}$
(c) $7.69 \times 10^3 \text{ L}$ (d) 76.9 L

JEE & AIEEE Compendium

- 41.** The mass of potassium dichromate crystals required to oxidise 750 cm^3 of 0.6 M Mohr's salt solution is (Given, molar mass : potassium dichromate = 294, Mohr's salt = 392) (AIEEE 2011)
(a) 0.49 g (b) 0.45 g
(c) 22.05 g (d) 2.2 g
- 42.** A student performs a titration with different burettes and finds titre values of 25.2 mL, 25.25 mL and 25.0 mL. The number of significant figures in the average titre value is (IIT JEE 2010)
(a) 1 (b) 2
(c) 3 (d) 4
- 43.** In the reaction,
$$2\text{Al}(\text{s}) + 6\text{HCl}(\text{aq}) \longrightarrow 2\text{Al}^{3+}(\text{aq}) + 6\text{Cl}^{-}(\text{aq}) + 3\text{H}_2(\text{g})$$
(AIEEE 2007)
(a) 6L $\text{HCl}(\text{aq})$ is consumed for every 3L, $\text{H}_2(\text{g})$ produced
(b) 33.6 L $\text{H}_2(\text{g})$ is produced regardless of temperature and pressure for every mole Al that reacts
(c) 67.2 L $\text{H}_2(\text{g})$ at STP, is produced for every mole Al that reacts
(d) 11.2 L $\text{H}_2(\text{g})$ at STP, is produced for every mole $\text{HCl}(\text{aq})$ consumed
- 44.** How many moles of magnesium phosphate, $\text{Mg}_3(\text{PO}_4)_2$ will contain 0.25 mole of oxygen atoms? (AIEEE 2006)
(a) 0.02 (b) 3.125×10^{-2}
(c) 1.25×10^{-2} (d) 2.5×10^{-2}
- 45.** If we consider that 1/6 in place of 1/12, mass of carbon atom is taken to be the relative atomic mass unit, the mass of one mole of a substance will (AIEEE 2005)
(a) to be a function of the molecular mass of the substance
(b) remain unchanged
(c) increase two fold
(d) decrease twice
- 46.** Two solutions of a substance (non-electrolyte) are mixed in the following manner : 480 mL of 1.5 M of first solution with 520 mL of 1.2 M of second solution. The molarity of final solution is (AIEEE 2005)
(a) 1.20 M (b) 1.50 M
(c) 1.344 M (d) 2.70 M
- 47.** Which has maximum number of atoms? (IIT JEE 2003)
(a) 24g of C(12)
(b) 56g of Fe(56)
(c) 27g of Al(27)
(d) 108g of Ag(108)

48. Mixture X = 0.02 mole of $[\text{Co}(\text{NH}_3)_5\text{SO}_4]\text{Br}$ and 0.02 mole of $[\text{Co}(\text{NH}_3)_5\text{Br}]\text{SO}_4$ was prepared in 2 L of solution.
 1 L of mixture X + excess $\text{AgNO}_3 \longrightarrow \text{Y}$
 1 L of mixture X + excess $\text{BaCl}_2 \longrightarrow \text{Z}$
 Number of moles of Y and Z are (IIT JEE 2003)
 (a) 0.01, 0.01 (b) 0.02, 0.01
 (c) 0.01, 0.02 (d) 0.02, 0.02
49. What volume of hydrogen gas at 273K and 1 atm pressure will be consumed in obtaining 21.6 g of elemental boron (atomic mass = 10.8) from the reduction of boron trichloride by hydrogen? (AIEEE 2003)
 (a) 89.6 L (b) 67.2 L (c) 44.8 L (d) 22.4 L
50. How many moles of electron weigh one kilogram? (IIT JEE 2002)
 (a) 6.023×10^{23} (b) $\frac{1}{9.108} \times 10^{31}$
 (c) $\frac{6.023}{9.108} \times 10^{54}$ (d) $\frac{1}{9.108 \times 6.023} \times 10^8$
51. In an organic compound of molar mass 108 g mol^{-1} C, H and N atoms are present in 9 : 1 : 3.5 by weight. Molecular formula can be (AIEEE 2002)
 (a) $\text{C}_6\text{H}_8\text{N}_2$
 (b) $\text{C}_6\text{H}_{10}\text{N}_5$
 (c) $\text{C}_5\text{H}_6\text{N}_3$
 (d) $\text{C}_4\text{H}_{18}\text{N}_3$

Answers

- | | | | | | | | | | |
|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| 1. (c) | 2. (c) | 3. (b) | 4. (c) | 5. (c) | 6. (a) | 7. (c) | 8. (c) | 9. (a) | 10. (c) |
| 11. (d) | 12. (c) | 13. (a) | 14. (d) | 15. (a) | 16. (d) | 17. (a) | 18. (a) | 19. (a) | 20. (d) |
| 21. (a) | 22. (a) | 23. (b) | 24. (b) | 25. (b) | 26. (a) | 27. (a) | 28. (b) | 29. (a) | 30. (d) |
| 31. (d) | 32. (a) | 33. (a) | 34. (d) | 35. (c) | 36. (b) | 37. (c) | 38. (c) | 39. (a) | 40. (b) |
| 41. (c) | 42. (c) | 43. (d) | 44. (b) | 45. (b) | 46. (c) | 47. (a) | 48. (a) | 49. (b) | 50. (d) |
| 51. (a) | | | | | | | | | |

Hints & Solutions

1. $18 \text{ mL H}_2\text{O} = 18 \text{ g H}_2\text{O} = 1 \text{ mol}$
 $= 6.02 \times 10^{23}$ molecules
 $= 10 \times 6.02 \times 10^{23}$ electrons
 $= 6.02 \times 10^{24}$ electrons
2. $\therefore 18 \text{ mL} = 18 \text{ g}$ of water contains = 20×18 drops
 $= A$ molecules
 $\therefore 1$ drop contains = $\frac{A}{20 \times 18}$ molecules = $\frac{0.05 A}{18}$ molecules
3. 6.02×10^{24} CO molecules = 10 moles CO
 $= 10 \text{ g atoms of O} = 5 \text{ g molecules of O}_2$
4. $\therefore 6.02 \times 10^{23}$ molecules of $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$
 $= 63.5 + 32 + 64 + 90 = 249.5 \text{ g}$
 $\therefore 10^{22}$ molecules of $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$
 $= \frac{249.5}{6.02 \times 10^{23}} \times 10^{22} = 4.15 \text{ g}$
5. As the given sulphate, is isomorphous with $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$, its formula would be $\text{MSO}_4 \cdot 7\text{H}_2\text{O}$. If m is the atomic weight of M , molecular weight of
 $\text{MSO}_4 \cdot 7\text{H}_2\text{O} = m + 32 + 64 + 126 = m + 222$
 Hence, % of $M = \frac{m}{m + 222} \times 100 = 9.87$ (given)
 or $100m = 9.87m + 222 \times 9.87$
 or $90.13m = 222 \times 9.87$
 or $m = 24.3$
6. I. 1 molecule of $\text{O}_2 = \frac{32}{6.022 \times 10^{23} \text{ g}}$
 $= 5.3 \times 10^{-23} \text{ g}$
 II. 1 atom of N = $\frac{14}{6.022 \times 10^{23} \text{ g}} = 2.3 \times 10^{-23} \text{ g}$
 III. $10^{-10} \text{ g mol. wt. of oxygen}$
 $= 10^{-10} \times 32 = 3.2 \times 10^{-9} \text{ g}$
 IV. $10^{-10} \text{ g atomic weight of copper}$
 $= 10^{-10} \times 63 = 6.3 \times 10^{-9} \text{ g}$
 \therefore Order of increasing mass is II < I < III < IV
7. $\text{Ca}_3\text{P}_2 + 6\text{H}_2\text{O} \longrightarrow 3\text{Ca}(\text{OH})_2 + 2\text{PH}_3$
8. H_3PO_2 disproportionates as

$$2\overset{+1}{\text{H}_3\text{P}\text{O}_2} \longrightarrow \overset{-3}{\text{P}\text{H}_3} + \overset{+5}{\text{H}_3\text{P}\text{O}_4}$$
 Molecular wt. of $\text{H}_3\text{PO}_2 = 3 + 31 + 32 = 66$
 \therefore Eq. wt. = $\frac{66}{4} + \frac{66}{4} = 33$
9. $0.1 \text{ L} = 100 \text{ mL}$ has Pb = $30 \text{ mg} = 30 \times 10^{-6} \text{ g}$
 $= \frac{30 \times 10^{-6}}{207} \text{ mol of Pb}$