DAY ONE

Some Basic Concepts of Chemistry

Learning & Revision for the Day

- Importance and Scope of Chemistry
- Physical Quantities and their Measurements
- Law of Chemical Combinations
- Dalton's Atomic Theory
- Atomic and Molecular mass
- Equivalent Weight
- Mole Concept
- Stoichiometry and Calculation Based on Stoichiometry
- Limiting Reagent

Importance and Scope of Chemistry

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

Different manifestation of chemistry include drugs, polymers, dyes, soaps, detergents, acids, bases, salts, metals, alloys, etc.

Matter Anything that occupies space and possesses mass is called matter. On the basis of chemical composition of substance, matter can be:

(i) **Elements** are the substances that cannot be decomposed into simpler substances by chemical change, e.g. Na, Mg, Al etc.

(ii) **Compounds** can be decomposed into simpler substances by chemical changes. Compound is always homogeneous. Properties of a compounds are different from the properties of its constituent elements, e.g. H_2O, NaCl, $CaCO_3$ etc.

(iii) **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.

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.

- A number of quantities must be derived from measured value of the SI base quantities. These are called derived units, e.g. units of density (kg m^{-3}) is derived from the units of mass (kg) and volume (m^{-3}).

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

The Seven Basic 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

Significant Figures

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

Rules for reporting significant figures are as follows :

- Read the number from left to right and count all the digits, starting with the first digit that is not zero.
- While adding or subtracting, the number of decimal places in the answer should not exceed the number of decimal places in either of the numbers.
- In multiplication and division, the result should be reported to the same number of significant figures as that in the quantity with least number of significant figures.
- When a number is rounded off, the number of significant figures is reduced. The last digit retained is increased by 1 only if the following digit is >5 and is left as such if the following digit is < 4.
- If the right most digit to be removed is 5 then the preceeding number is not changed, if it is even number but it is increased by one if it is an odd number.

Laws of Chemical Combinations

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

(i) **Law of Conservation of Mass** (Lavoisier, 1789) It states that "mass is neither created nor destroyed in chemical reactions."
Total mass of reactants = total mass of products.

(ii) **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.

(iii) **Law of Multiple Proportions** (Dalton, 1803) An element may form more than one compound with another element. The masses of one element that combine with a fixed mass of another element are in the ratio of small whole number, e.g. in NH_3 and N_2H_4, fixed mass of nitrogen requires hydrogen in the ratio 3 : 2.

(iv) **Law of Reciprocal Proportions** (Richter, 1792) When two different elements combines with a fixed weight of a third element, the ratio of their combination will either be same or multiple of the ratio in which they combine with each other, e.g. CH_4, CO_2 and H_2O.

(v) **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.

(vi) **Avogadro's Law** This law is based on Berzelius hypothesis. According to this law, equal volumes of gases at the same temperature and pressure should contain equal number of molecules.

$$1 \text{ mole} = \text{atomic/molecular weight}$$
$$= 22.4 \text{ L at STP}$$
$$= 6.02 \times 10^{23} \text{ atoms/molecules/ions}$$

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 or molecule, in simple whole number ratio.
- Atoms of same element are identical in mass and chemical properties.

Atomic and Molecular Mass

- **Atomic mass** is defined as the number which indicates how many times the mass of one atom of the element is heavier as compared to 1/12th part of the mass of one atom of C-12. The gram atomic mass of an element should not be confused with the actual mass of their atoms. e.g. Gram atomic mass of H-element is 1.008 g but mass of H atom is 1 μ $[1.67 \times 10^{-24}$ g].
- **Average atomic mass** since most of the elements have isotopes, so their actual atomic mass is the average of atomic masses of all the isotopes as present by % in nature and hence, generally in fraction. Average atomic mass is calculated as,

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

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

- **Molecular mass** is defined as the sum of atomic masses of the elements present in a molecule. Thus, it is obtained by multiplying the atomic mass of each element by the number of its atoms and then adding them together e.g.,

Molecular mass of methane can be calculated as

$$CH_4 = 1 \times \text{atomic mass of C} + 4 \times \text{atomic mass of H}$$
$$= (12.011\text{u}) + 4\ (1.008\text{ u})$$
$$= 16.043\text{ u}$$

- Molecular weight can be determined using following methods :
  (i) Molecular weight $= 2 \times$ vapour density
  (ii) **Victor Meyer Method** The method is used to determine the molecular weight of volatile organic compounds only.

  Molecular weight of volatile organic compound

$$= \frac{\text{Mass of volatile organic compound} \times 22{,}400}{\text{Volume of volatile organic compound}}$$

Equivalent Weight

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

Equivalent weight and strength are related as

$$\text{Eq. wt.} = \frac{\text{Strength}}{\text{Normality}}$$

Equivalent weight (Eq. wt.)

$$= \frac{\text{Atomic weight or molecular weight}}{n\text{-factor}}$$

n-factor for various compounds can be obtained as:

(i) ***n*-factor for acids, i.e. basicity** is the number of ionisable H^+ per molecule and is called the basicity of an acid.

e.g. Basicity of $HCl = 1$

(ii) ***n*-factor for bases, i.e. acidity** is the number number of ionisable OH^- per molecule and is called the acidity of a base. e.g. Acidity of $NaOH = 1$

(iii) ***n*-factor for salt** is the total positive or negative charge of ions. e.g. $Na_2CO_3 \longrightarrow 2N\overset{+}{a} + CO_3^{2-}$

(iv) ***n*-factor for ion** is equal to charge of that ion.

e.g. $E_{Cl^-} = \frac{35.5}{1}$

$= 35.5$

(v) **In redox titration** *n*-factor for reducing agent is number of electrons lost by the molecule and for oxidising agent is number of electrons gained by the molecule.

Equivalent weight can be determined by following methods:

(i) **Oxide Formation Method** This method is used to find out the equivalent mass of those metals, which can easily form their oxides.

$$\text{Eq. wt. of metal} = \frac{\text{Mass of metal}}{\text{Mass of oxygen combined}} \times 8$$

(ii) **Hydrogen Displacement Method** The known mass of a metal react with dilute acids and volume of hydrogen produced is measured and equivalent weight is calculated as :

$$= \frac{\text{Mass of metal}}{\text{Mass of } H_2 \text{ displaced}} \times 1.008$$

(iii) **Chloride Formation Method** A known mass of metal is reacted with chlorine. Mass of chloride obtained is measured. Equivalent weight of metal

$$= \frac{\text{Mass of metal}}{\text{Mass of chlorine combined}} \times 100$$

(iv) **Double Decomposition Method** A known mass of compound (*AB*) is treated with compound (*CD*).

$$AB + CD \longrightarrow AD + CB$$

The atomic mass is calculated as :

$$\frac{\text{Mass of } AB}{\text{Mass of } CB} = \frac{\text{Eq. mass of } AB}{\text{Eq. mass of } CB} = \frac{E_A + E_B}{E_C + E_B}$$

(v) **Metal Displacement Method** A known mass of metal is added to the solution of salt of other metal.

Metal A + salt of B metal $\longrightarrow$ Salt of metal A + metal B

Equivalent weight is calculated as:

$$\frac{\text{Mass of metal } A}{\text{Mass of metal } B} = \frac{\text{Eq. mass of } A}{\text{Eq. mass of } B}$$

(vi) **Electrolytic Method** The same quantity of electricity is passed through the solution of different electrolytes, the masses of different substances liberated are measured. Eq. wt. is calculated as

$$\frac{w_1}{w_2} = \frac{E_1}{E_2}$$

where, w_1 and w_2 are mass of first and second substance deposited.

E_1 and E_2 are eq. wt. of first and second substance.

(vii) **Silver Salt Method** The method is used to determine the equivalent weight of organic acids only

Equivalent weight of organic acid

$$= \frac{108 \times \text{weight of silver salt}}{\text{weight of silver metal}} - 107$$

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. Mole is related to the mass of the substance (in grams).

Therefore, number of moles

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

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

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

Total number of atoms/molecules/ions/electrons

$= \text{mole} \times N_A \times$ number of electrons/atoms/ions in one molecule.

Total charge present on an ion

$= \text{mole} \times N_A \times \text{charge on one ion} \times 1.6 \times 10^{-19}$ C

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 weight 32 g.

Various Concentration Terms

Concentration of solution can be classified as:

(i) **Mole Fraction** (χ) It is fraction of substance in mixture expressed in terms of mole. Let n_A and n_B are number of moles of A and B in a mixture.

Then, mole fraction of $A = \chi_A = \dfrac{n_A}{n_A + n_B}$

mole fraction of $B = \chi_B = \dfrac{n_B}{n_A + n_B}$

Sum of mole fractions of all components of mixture is 1.

(ii) **Molarity** (M) It is the number of moles of solute present in per litre of the solution.

$$\text{Molarity } (M) = \frac{\text{Number of moles of solute}}{\text{Litres of solution}}$$

(iii) **Normality** (N) It is the concentration of solution expressed in number of gram equivalents dissolved per litre of solution.

$$\text{Normality } (N) = \frac{\text{Number of gram equivalents}}{\text{Solution in litres}}$$

(iv) **Molality** (m) It is defined as the number of moles of solute dissolved in 1000g of the solvent.

or,

$$\text{Molality } (m) = \frac{\text{Moles of solute } (n)}{\text{Weight of solvent } (W_A) \text{ (in kg)}} \times 1000$$

or, $\quad (m) = \dfrac{n \times 1000}{W_A \text{ (in g)}}$

Percentage Composition, Empirical and Molecular Formulae

We can calculate the amount of elements and their percentage composition using the formula given below :

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

Stoichiometry and Calculation Based on Stoichiometry

A balanced chemical equation with suitable stoichiometric coefficients represents the ratio of number of moles of reactants and products.

For example, in the given reaction, H_2 and O_2 reacts in 2 : 1 to form 2 moles of H_2O.

$$2H_2(g) + O_2(g) \longrightarrow 2H_2O(g)$$

The equation provides quantitative and qualitative information that helps in solving following problems:

(i) **Mass/Mass Relationship** In this relationship, mass of one of the reactant/product is to be calculated, if mass of the other is given.

(ii) **Mole/Mole Relationship** Mole of one of the reactant/product is to be calculated, if mole of other is given.

(iii) **Mass/Volume Relationship** Mass or volume of one of the reactant or product is calculated from mass/volume of other substance.

(iv) **Mass/Mole Relationship** Mass or mole of one of the reactants/products is to be calculated if mole or mass of other is given.

(v) **Volume/Volume Relationship** Volume of one of reactants/ products is to be calculated if volume of other is given.

NOTE Equivalents of reactants react to give same number of equivalents of products whereas moles react according to stoichiometry of equation.

Limiting Reagent

Limiting reagent is the substance which is completely consumed first in a reaction is called limiting reagent. It determines

the amount of product. Reaction yield $= \dfrac{\text{Actual yield} \times 100}{\text{Theoretical yield}}$

It must be noted that 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).

DAY PRACTICE SESSION 1

FOUNDATION QUESTIONS EXERCISE

1 How many significant figures should be present in the following calculation?

$$\frac{2.5 \times 1.25 \times 3.5}{2.01}$$

(a) 2 (b) 3 (c) 4 (d) 6

2 $^{35}_{17}Cl$ and $^{37}_{17}Cl$ are two isotopes of chlorine. If average atomic mass is 35.5, then ratio of these two isotopes is

(a) 35 : 37 (b) 1 : 3 (c) 3 : 1 (d) 2 : 1

3 If Avogadro number N_A, is changed from 6.022×10^{23} mol^{-1} to 6.022×10^{20}mol^{-1} this would change

(a) the definition of mass in units of grams
(b) the mass of one mole of carbon
(c) the ratio of chemical species to each other in a balanced equation
(d) the ratio of elements to each other in a compound

4 Two oxides of a metal contain 53.4% and 36.4% of oxygen by mass respectively. If the formula of first oxide is MO , then that of the second is

(a) MO (b) M_2O (c) M_2O_5 (d) MO_2

5 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

6 A gas is found to have a formula $(CO)_x$. If its vapour density is 70, the value of x is

(a) 2.3 (b) 3.0 (c) 5.0 (d) 6.0

7 The equivalent weight of H_3PO_2, when it disproportionates into PH_3 and H_3PO_3 is

(a) 82 (b) 61.5 (c) 41 (d) 20.5

8 0.45 g acid of molecular weight 90 was neutralise by 20 mL of 0.5 N KOH. The basicity of acid is

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

9 One mole of any substance contains 6.022×10^{23} atoms/molecules. Number of molecules of H_2SO_4 present in 100 mL of 0.02M H_2SO_4 solution is

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

10 6.02×10^{20} molecules of urea are present in 100mL of its solution. The concentration of solution is → **NEET 2013**

(a) 0.02 M (b) 0.01 M (c) 0.001 M (d) 0.1 M

11 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

12 A mixture of 2.3 g formic acid and 4.5 g oxalic acid is treated with conc. H_2SO_4. The evolved gaseous mixture is passed through KOH pellets. Weight (in g) of the remaining products at STP will be → **NEET 2018**

(a) 2.8 (b) 3.0 (c) 1.4 (d) 4.4

13 The number of atoms in 0.1 mole of a triatomic gas is ($N_A = 6.02 \times 10^{23}$ mol^{-1}) → **CBSE-AIPMT 2010**

(a) 6.026×10^{22} (b) 1.806×10^{23}
(c) 3.600×10^{23} (d) 1.800×10^{22}

14 When 22.4 L of $H_2(g)$ is mixed with 11.2 L of $Cl_2(g)$ each at STP, the moles of HCl (g) formed is equal to → **CBES-AIPMT 2014**

(a) 1 mole of HCl (g)
(b) 2 moles of HCl (g)
(c) 0.5 mole of HCl (g)
(d) 1.5 mole of HCl (g)

15 A sample of commercial sulphuric acid is 98% H_2SO_4 by mass. The mole fractions of H_2SO_4 and H_2O are

(a) 0.9, 0.1 (b) 0.1, 0.9 (c) 0.2, 0.8 (d) 0.8, 0.2

16 Mass of one atom of X is 2.66×10^{-23}g, then its 32 g is equal to

(a) $32 \times 2.66 \times 10^{-23}$ mol
(b) $\frac{32}{2.66 \times 10^{-23} \times 6.023 \times 10^{23}}$ mol
(c) $\frac{32 \times 2.66 \times 10^{-23}}{6.02 \times 10^{23}}$ mol
(d) None of the above

17 Equal volumes of 0.1 M $AgNO_3$ and 0.2 M NaCl are mixed. The concentration of NO_3^- ions in the mixture will be

(a) 0.1 M (b) 0.05 M
(c) 0.2 M (d) 0.15 M

18 Concentrated aqueous sulphuric acid is 98% H_2SO_4 by mass and has a density of 1.80 g mL^{-1}. Volume of acid required to make one litre of 0.1 M H_2SO_4 solution is

(a) 11.10 mL (b) 16.65 mL
(c) 22.20 mL (d) 5.55 mL

19 What is the percentage of cation in ammonium dichromate?

(a) 14.29% (b) 80%
(c) 50.05% (d) 20.52%

20 The isotopic abundance of C-12 and C-14 is 98% and 2%, respectively. What would be the number of C-14 isotope in 12 g carbon sample?

(a) 1.032×10^{22} (b) 3.01×10^{23}
(c) 5.88×10^{23} (d) 6.02×10^{23}

21 What volume of a solution of hydrochloric acid containing 73g of acid per litre would sufficient for exact neutralisation of sodium hydroxide obtained by allowing 0.46 g of metallic sodium to act upon water? ($Cl = 35.5$, $Na = 23.0$, $O = 16$)

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

22 Suppose the elements X and Y combine to form two compounds XY_2 and X_3Y_2. When 0.1 mole of XY_2 weighs 10 g and 0.05 mole of X_3Y_2 weighs 9 g, the atomic weights of X and Y are **→ NEET 2016, Phase II**

(a) 40, 30 (b) 60, 40
(c) 20, 30 (d) 30, 20

23 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

24 1.0 g of magnesium is burnt with 0.56 g O_2 in a closed vessel. Which reactant is left in excess and how much? (At.wt. of Mg = 24; O = 16)

(a) Mg, 0.16 g (b) O_2, 0.16 g
(c) Mg, 0.44 g (d) O_2, 0.28 g

25 10^{21} molecules are removed from 200mg of CO_2. The moles of CO_2 left are

(a) 2.88×10^{-3} (b) 28.8×10^{-3}
(c) 288×10^{-3} (d) 28.8×10^{-3}

26 An aqueous solution of glucose is 10% in strength. The volume in which 1g mole of it is dissolved will be

(a) 18 L (b) 92 L
(c) 0.9 L (d) 1.8 L

27 The decomposition of a certain mass of $CaCO_3$ gave 11.2 dm^3 of CO_2 gas at STP. The mass of KOH required to completely neutralise the CO_2 is

(a) 56 g (b) 28 g
(c) 42 g (d) 20 g

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

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

Direction (Q. Nos. 29-30) *Each of these questions contains two statements : Statement* I *and* II. *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 for Statement I
(b) Statement I is true, Statement II is true; Statement II is not a correct explanation for Statement I
(c) Statement I is true, Statement II is false
(d) Statement I is false, Statement II is true

29 **Statement I** Equivalent weight of ozone in the change $O_3 \rightarrow O_2$ is 8.

Statement II 1 mole of O_3 on decomposition gives $\frac{3}{2}$ moles of O_2.

30 **Statement I** The molality of the solution does not change with change in temperature.

Statement II The molality of the solution is expressed in units of moles per 1000 g of solvent.

DAY PRACTICE SESSION 2

PROGRESSIVE QUESTIONS EXERCISE

1 Two parts of an element P combines with four parts of another element Q. Six parts of the element R combine with four parts of the element Q. If P and R combine together, the ratio of their weight will be governed by

(a) law of multiple proportions
(b) law of reciprocal proportions
(c) law of conservation of mass
(d) law of definite proportions

2 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

3 The vapour density of a volatile chloride of a metal is 95 and the specific heat of the metal is 0.13 cal/g. The equivalent weight of the metal will be approximately

(a) 6 (b) 12
(c) 18 (d) 49

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

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

5 0.5 g of fuming H_2SO_4 (oleum) is diluted with water. This solution is completely neutralised by 26.7 mL of 0.4 N NaOH. The percentage of free SO_3 in the sample is

(a) 30.6% (b) 40.6%
(c) 20.6% (d) 50%

6 100 mL each of 0.5 N NaOH, N/5 HCl and N/10 H_2SO_4 are mixed together. The resulting solution will be

(a) acidic (b) neutral
(c) alkaline (d) None of these

7 In a compound C, H and N are present in 9 : 1 : 3.5 by weight. If molecular weight of compound is 108, the molecular formula of compound is

(a) $C_2H_6N_2$ (b) C_3H_4N
(c) $C_6H_8N_2$ (d) $C_9H_{12}N_3$

8 The vapour density of a mixture of NO_2 and N_2O_4 is 38.3 at 26.7°C. The number of moles of NO_2 in 200 g of the mixture are

(a) 0.437 (b) 0.874
(c) 0.824 (d) 1.758

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

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

10 Number of atoms in 560 g of Fe is
(Given, atomic mass of Fe = 56 g mol^{-1})

I. twice that of 70 g N
II. half that of 20 g H
III. half that of 72 g C
IV. twice that of 40 g N

Choose the corret options

(a) I, II and III are correct (b) I and II are correct
(c) II and IV are correct (d) I and III are correct

11 If 1 mL of water contains 20 drops, then number of molecules in one drop of water is

(a) 6.023×10^{23} (b) 1.376×10^{26}
(c) 1.344×10^{18} (d) 4.346×10^{20}

12 The mass of carbon anode consumed (given only CO_2) in production of 270 kg of aluminium metal from bauxite by the Hall process is (atomic mass of Al = 27)

(a) 180 kg (b) 270 kg
(c) 540 kg (d) 90 kg

13 A sample of $CaCO_3$ is 50% pure. On heating, 1.12 L of CO_2 (at STP) is obtained. Residue left (assuming non-volatile impurity) is

(a) 7.8 g (b) 3.8 g
(c) 2.8 g (d) 8.9 g

14 Sulphuric acid reacts with sodium hydroxide follows

$$H_2SO_4 + 2NaOH \longrightarrow Na_2SO_4 + 2H_2O$$

When 1L of 0.2M sulphuric acid solution is allowed to react with 1L of 0.2M sodium hydroxide solution, the amount of sodium sulphate formed and its molarity in the solution obtained respectively is

(a) 14.2g, 0.05 $molL^{-1}$
(b) 7.1g, 0.05 $molL^{-1}$
(c) 14.2g, 0.1 $molL^{-1}$
(d) 7.1g, 0.1 $molL^{-1}$

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

Reason H_2 is the liniting reapent.

(a) Assertion is true, Reason is true; Reason is a correct explanation for Assertion
(b) Assertion is true, Reason is true; Reason is not a correct explanation for Assertion
(c) Assertion is true, Reason is false
(d) Assertion is false, Reason is true

ANSWERS

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

Hints and Explanations

SESSION 1

1 Least precise term 2.5 has two signficant figures. Hence, the answer should have two significant figures

$$\frac{2.5\times 1.25\times 3.5}{2.01} = 5.4415 \approx 5.4$$

2 Average atomic mass,

$$\overline{A} = \frac{x\times a + y\times b}{x+y}$$

$$35.5 = \frac{35x_1 + 37y_2}{x_1 + y_2}$$

$$\frac{x_1}{y_2} = \frac{3}{1} \quad \therefore x_1 : y_2 = 3:1$$

3 If Avogadro number N_A, is changed from 6.022×10^{23} mol^{-1}, to 6.022×10^{20} mol^{-1} this would change the mass of one mole of carbon.

$\because$ 1 mole of carbon has mass $=12$ g

or 6.022×10^{23} atoms of carbon have mass $=12$ g

$\therefore$ 6.022×10^{23} atoms of carbon have

$$\text{mass} = \frac{12}{6.022\times 10^{23}}\times 6.022\times 10^{20}$$

$$=0.012 \text{ g}$$

4 In 2nd oxide, 36.4 parts of O combine with 63.6 parts of M

$\therefore$ O present $=36.4$ parts

M present $=63.6$ parts

31.8 parts of $M = 1$ atom of M

$\therefore$ 63.6 parts of $M = 2$ atoms of M

36.4 parts of O $=1$ atom of O

$\therefore$ In second oxide, M : O $=2:1$

Hence, formula of second oxide $=M_2O$

5 Mass of oxygen in oxide

$= 4-2.8 = 1.2$ g

Equivalent weight of metal

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

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

Valency of metal

$$= \frac{\text{Atomic weight of metal}}{\text{Equivalent weight of metal}}$$

$$= \frac{56}{18.67} = 2.99 \approx 3$$

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

6 Molecular weight $= 2\times$ vapour density

$$= 2\times 70 = 140$$

$\therefore \quad (CO)_x = 140$

$\Rightarrow \quad (12+16)x = 140$

$\therefore \quad (28)x = (28)\times 5 \Rightarrow x = 5$

7 The reaction can be written as

$$3H_3\overset{+1}{P}O_2 \longrightarrow \overset{-3}{P}H_3 + 2H_3\overset{+3}{P}O_3$$

Molecular weight of H_3PO_3

$= 3+31+48 = 82$

$$\text{Equivalent weight} = \frac{82}{1-(-3)} + \frac{82}{1-3}$$

$$= \frac{82}{4} + \frac{82}{2} = 61.5$$

8 $\text{Basicity} = \dfrac{\text{Molecular weight}}{\text{Equivalent weight}}$

Now, gram equivalents of acid

= gram equivalents of KOH

$$\Rightarrow \frac{0.45}{E} = \frac{20\times 0.5}{1000} \Rightarrow E = 45$$

$\therefore$ Basicity $=2$

9 One mole of any substance contains

6.022×10^{23} atoms/molecules.

Hence, number of millimoles of H_2SO_4

= molarity $\times$ volume in mL

$0.02\times 100 = 2$ millimoles

$= 2\times 10^{-3}$ mol

Number of molecules

= Number of moles $\times N_A$

$= 2\times 10^{-3}\times 6.022\times 10^{23}$

$= 12.044\times 10^{20}$ molecules

10 Given, number of molecules of urea

$= 6.02\times 10^{20}$

$$\text{Number of moles} = \frac{6.02\times 10^{20}}{N_A}$$

$$= \frac{6.02\times 10^{20}}{6.023\times 10^{23}} = 0.999\times 10^{-3}$$

$$\approx 1\times 10^{-3}\text{mol}$$

Volume of the solution

$$= 100\text{ mL} = \frac{100}{1000}\text{ L} = 0.1\text{ L}$$

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

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

$= 0.01$ mol L^{-1}

11 (i) Number of moles (n_{H_2O})

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

$w_{H_2O} = 18$ g

[$\because$ Density of water (d_{H_2O}) $=1$ gL^{-1}]

$$\therefore \quad n_{H_2O} = \frac{18}{18} = 1$$

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

(ii) 0.18 g of water,

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

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

(iii) 0.00224 L of water vapours at 1 atm and 273 K.

At STP [1atm and 273 K],

Number of moles [with refrence to volume]

$$= \frac{\text{Volume of gas in litre}}{22.4} = \frac{0.00224}{22.4} = 0.0001$$

(iv) 10^{-3} mol of water

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

12

$$\underset{\text{Formic acid}}{HCOOH} \xrightarrow{\text{Conc. } H_2SO_4} CO(g) + H_2O(l)$$

	HCOOH	CO(g)
Initial moles	$\frac{2.3}{46} = \frac{1}{20}$ mol	0
Final moles	0	$\frac{1}{20}$

Similarly,

$$\underset{\text{Oxalic acid}}{\begin{matrix}COOH\\ |\\ COOH\end{matrix}} \xrightarrow{\text{Conc. } H_2SO_4} CO(g) + CO_2(g) + H_2O(l)$$

	(COOH)$_2$	CO(g)	CO$_2$(g)
Initial moles	$\frac{4.5}{90} = \frac{1}{20}$ mol	0	0
Final moles	0	$\frac{1}{20}$	$\frac{1}{20}$

Now, $H_2O(l)$ gets absorbed by conc. H_2SO_4. Gaseous mixture CO and CO_2 when passed through KOH, only CO_2 gets absorbed. Thus, CO is the remaining gas. Total number of moles of CO formed in the above equations

$$= \frac{1}{20} + \frac{1}{20} = \frac{1}{10}$$

$$\therefore \text{ Moles} = \frac{\text{Weight}}{\text{Molar mass}}$$

or, weight of CO formed $= \dfrac{1}{10}\times 28 = 2.8$ g

13 Number of atoms

$= \text{number of moles} \times N_A \times \text{atomicity}$

$= 0.1 \times 6.02 \times 10^{23} \times 3$

$= 1.806 \times 10^{23}$ atoms

14 $H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$

Initial volume 22.4 L 11.2 L 2 mol

22.4 L volume at STP is occupied by $Cl_2 = 1$ mol

$\therefore$ 11.2 L volume will be occupied by

$Cl_2 = \frac{1 \times 11.2}{22.4}$ mol

$= 0.5$ mol

Thus, $\underset{1\text{ mol}}{H_2(g)} + \underset{0.5\text{ mol}}{Cl_2(g)} \longrightarrow 2HCl(g)$

Since, Cl_2 possesses minimum number of moles, thus it is the limiting reagent.

As per equations,

$1 \text{ mol } Cl_2 = 2 \text{L mol HCl}$

$\therefore \quad 0.5 \text{ mol } Cl_2 = 2 \times 0.5 \text{ mol HCl}$

$= 1.0 \text{ mol HCl}$

Hence, 1.0 mol of HCl (g) is produced by 0.5 mole of Cl_2 [or 11.2 L]

15 Consider 100 g of solution. Thus,

$m_{H_2SO_4} = 98\text{g}, m_{H_2O} = 2\text{g}$

$n_{H_2SO_4} = \frac{\text{Mass of } H_2SO_4}{\text{Molar mass of } H_2SO_4}$

$= \frac{98 \text{ g}}{98 \text{ g mol}^{-1}} = 1 \text{ mol}$

$n_{H_2O} = \frac{\text{Mass of } H_2O}{\text{Molar mass of } H_2O}$

$= \frac{2 \text{ g}}{18 \text{ g mol}^{-1}} = \frac{1}{9} \text{ mol}$

$\chi_{H_2SO_4} = \frac{n_{H_2SO_4}}{n_{H_2SO_4} + n_{H_2O}} = \frac{1\text{mol}}{(1+1/9) \text{ mol}}$

$= \frac{1}{10/9} = \frac{10}{9} = 0.9$

$\chi_{H_2O} = 1.0 - \chi_{H_2SO_4} = 1.0 - 0.9 = 0.1$

16 Mass of one atom $= 2.66 \times 10^{-23}$ g

Mass of N_0 atoms

$= 2.66 \times 10^{-23} \times 6.023 \times 10^{23} \text{ g mol}^{-1}$

$=$ atomic mass

Thus, number of moles in 32 g

$= \frac{32}{2.66 \times 10^{-23} \times 6.023 \times 10^{23}}$ mol.

17 Millimoles of $AgNO_3 = 0.1 \times V$

Millimoles of NaCl $= 0.2 \times V$

Millimoles of $[NO_3^-] = 0.1 \times V$

Total volume of mixture $= V + V = 2V$

$[NO_3^-] = \frac{\text{millimoles of } [NO_3^-]}{\text{total volume}}$

$= \frac{0.1 \times V}{2V} = 0.05$

18 Normality $= \frac{\text{Weight} \times \text{density} \times 10}{\text{Equivalent weight}}$

$= \frac{98 \times 1.8 \times 10}{49} = 36 \text{ N}$

$\because \quad N_1V_1 = N_2V_2$

$\therefore \quad 36 \times V = 0.2 \times 1000$

$V = \frac{0.2 \times 1000}{36} = 5.55 \text{ mL}$

19 $(NH_4)_2Cr_2O_7$ has molecular weight 252.07 g/mol and ammonium cation have molecular weight 18.039 g/mol. Since, there are two ammonium cation per mole of ammonium dichromate.

Hence, % of NH_4^+

$= \frac{\text{Number of parts by weight } NH_4^+}{\text{Molecular weight of } (NH_4)_2Cr_2O_7} \times 100$

$= \frac{18.039 \text{ g/mol} \times 2}{252.07 \text{ g/mol}} \times 100 = 14.29\%$

20 Weight of C-14 isotope in 12 g sample

$= \frac{2 \times 12}{100}$

Number of C-14 isotope

$= \frac{2 \times 12 \times 6.02 \times 10^{23}}{100 \times 14}$

$= 1.032 \times 10^{22}$ atoms

21 $Na + H_2O \longrightarrow NaOH + \frac{1}{2}H_2$

$HCl + NaOH \longrightarrow NaCl + H_2O$

M_{eq} of Na $= M_{eq}$ of NaOH

$= M_{eq}$ of HCl

[M_{eq} = molarity equations

$M_1V_1 = M_2V_2$]

$\frac{0.46}{23} \times 1000 = \frac{73}{36.5} \times V$

$\left(M_{eq} = N \times V \text{ and } N\text{ (HCl)} = \frac{73}{36.5}\right)$

$\therefore \quad V = 10 \text{ mL}$

22 Let atomic masses of X and Y be A_X and A_Y, respectively

For XY_2, $n_{XY_2} = 0.1 = \frac{10}{A_X + 2A_Y}$

or $\quad A_X + 2A_Y = 100 \quad$ ...(i)

For $\quad X_3Y_2, n_{X_3Y_2} = 0.05 = \frac{9}{3A_X + 2A_Y}$

or $\quad 3A_X + 2A_Y = 180 \quad$ ...(ii)

On solving Eqs. (i) and (ii), we get

$A_X = 40 \text{ g mol}^{-1} \Rightarrow A_Y = 30 \text{ g mol}^{-1}$

23 $\underset{3 \times 56\text{g} = 168\text{g}}{3Fe} + \underset{4 \times 18\text{g} = 72\text{g}}{4H_2O} \longrightarrow Fe_3O_4 + 4H_2$

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

$\therefore$ 18 g steam require

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

24 The balanced chemical equation is

$\underset{24\text{ g}}{Mg} + \underset{16\text{ g}}{\frac{1}{2}O_2} \longrightarrow \underset{40\text{ g}}{MgO}$

From the above equation, it is clear that 24 g Mg reacts with 16 g O_2.

Thus, 1.0 g Mg reacts with

$\frac{16}{24} O_2 = 0.67 \text{ g } O_2$

But only 0.56 g O_2 is available, which is less than 0.67 g. Thus, O_2 is the limiting reagent.

Further, 16 g O_2 reacts with 24 g Mg.

$\therefore$ 0.56 g O_2 will react with Mg

$= \frac{24}{16} \times 0.56 = 0.84$ g

$\therefore$ Amount of Mg left unreacted

$= 1.0 - 0.84 = 0.16$ g Mg

Hence, Mg is present in excess and 0.16 g Mg is left behind unreacted.

25 1 mole of $CO_2 = 6.023 \times 10^{23}$ molecules of $CO_2 = 44$ g of CO_2

$\therefore 10^{21}$ molecules of CO_2

$= \frac{44}{6.023 \times 10^{23}} \times 10^{21} \text{ g } CO_2$

$= 7.31 \times 10^{-2} \text{g} = 73.1 \text{ mg}$

$\therefore CO_2$ left $= 200 - 73.1 = 126.9$ mg

Hence, moles of CO_2 left

$= \frac{126.9 \times 10^{-3}}{44} = 2.88 \times 10^{-3}$ mol

26 10% glucose solution means 10 g

$= \frac{10}{180}$ moles are present in 100 cc i.e. 0.1L

[Molecular weight of glucose

$C_6H_{12}O_6 = 180$]

Hence, 1 mole of glucose will present in

$= \frac{0.1 \times 180}{10} = 1.8$ L

27 $\underset{\substack{39 + 16 + 1 \\ = 56\text{ g}}}{KOH} + \underset{22.4 \text{ dm}^3}{CO_2} \longrightarrow KHCO_3$

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

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

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

28 $Mg_3(PO_4)_2$; 1 mol

8 moles of O-atom are contained by 1 mole of $Mg_3(PO_4)_2$.

Hence, 0.25 moles of O-atom are contained by

$= \frac{1}{8} \times 0.25 = 3.125 \times 10^{-2}$

29 $2O_3 \longrightarrow 3O_2$

2 mol $O_3 \equiv 3$ mol $O_2 = 3 \times 2$eq O_2

[M = molecular weight of O_3 = 48]

$E_{O_3} = \frac{M}{6} = \frac{48}{6} = 8$

30 Molality does not depend upon volume of the solution as molarity or normality. So, it does not depend upon temperature.

SESSION 2

1 For the given relations

(i) $2P + 4Q \rightarrow$ Products
(ii) $6R + 4Q \rightarrow$ Products
(iii) $x.P + y.R \rightarrow$ Products

According to the given relation; when two different elements combine with a fixed mass of a third element, the ratio of their combination will either same or multiple of the ratio in which they are combined with either.

e.g. CH_4, CO_2 and H_2O.

Hence law of reciprocal proportion will governed the above said relation.

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

In CO_2,

C = 27%, O = 73%

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

$\therefore$ 47 parts of oxygen will combine

$= \frac{27}{73} \times 47 = 17.38$ parts of C.

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

Hence, % of metal

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

3 Molecular weight of metal chloride

$= 95 \times 2 = 190$

[molecular weight = 2 × vapour density]

Atomic weight of metal $= \frac{6.4}{0.13} = 49.23$

Let the metal chloride be MCl_n.

$49.23 + n \times 35.5 = 190$

$n = 3.9 \approx 4$

Equivalent weight of metal

$= \frac{49.23}{4} = 12.3$

4 According to the question, the reaction occurs as

$$\underset{\substack{74 \\ (=1\,mol)}}{Ca(OH)_2} + \underset{\substack{44 \\ (=1\,mol)}}{CO_2} \longrightarrow \underset{\substack{100 \\ (=1\,mol)}}{CaCO_3} + \underset{\substack{18 \\ (=1\,mol)}}{H_2O}$$

Given, 50 mL of 0.5 M $Ca(OH)_2$ reacts with excess of CO_2.

$\therefore$ Number of millimoles of $Ca(OH)_2$ reacted = 25 mmol

$\because$ 1 mole of $Ca(OH)_2$ gives 1 mole of $CaCO_3$.

$\therefore$ Number of millimoles of $CaCO_3$ formed = 25 mmol

$\therefore$ Number of milliequivalent

$= \frac{\text{Weight (in mg)}}{\text{Equivalent weight}}$

$= \frac{25 \times 100}{50} = 50$

Number of milliequivalent of $CaCO_3$ = 50

As, volume of $CaCO_3$ solution = 50 mL

So, normality of $CaCO_3$ solution = 1 N

[milliequivalent = $N \times V$ (in mL)]

Normality of HCl = 0.1 N [given]

Volume of HCl = ?

$N_{HCl} \times V_{HCl} = N_{CaCO_3} \times V_{CaCO_3}$

$0.1 \times V_{HCl} = 1 \times 50$

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

5 Millieq. of H_2SO_4 + Millieq of SO_3

$\equiv$ Millieq of NaOH

$\frac{0.5 - a}{49} \times 1000 + \frac{a}{80/2} \times 1000 = 26.7 \times 0.4$

$\therefore a = 0.103$

% of $SO_3 = \frac{0.103}{0.5} \times 100 = 20.6\%$

6 Millieq. of NaOH = 100 × 0.5 = 50

Millieq. of HCl $= \left(\frac{1}{5}\right) \times 100 = 20$

Millieq. of $H_2SO_4 = \left(\frac{1}{10}\right) \times 100 = 10$

Total millieq. of acid = 20 + 10 = 30

Total millieq. of base (NaOH) = 50

Millieq. of NaOH left = 50 – 30 = 20

Thus, resulting solution is alkaline in nature.

7

Element	Ratio (by weight)	Atomic weight	Mole ratio	Simplest mole ratio
C	9	12	$\frac{9}{12} = 0.75$	$\frac{0.75}{0.25} = 3$
H	1	1	$\frac{1}{1} = 1.00$	$\frac{1.00}{0.25} = 4$
N	3.5	14	$\frac{3.5}{14} = 0.25$	$\frac{0.25}{0.25} = 1$

$\therefore$ Empirical formula = C_3H_4N

and empirical formula weight

$= 3 \times 12 + 4 \times 1 + 14 = 54$

Molecular weight = 108

$\because n = \frac{\text{molecular weight}}{\text{empirical formula of weight}}$

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

$\therefore$ Molecular formula

= (empirical formula)$_n$

$= (C_3H_4N)_2 = C_6H_8N_2$

8 Let, NO_2 present in 200g of the mixture $= x$ g

$\therefore N_2O_4$ present in the mixture

$= (200 - x)$ g

Molar mass of $NO_2 = 14 + 32 = 46\ g\ mol^{-1}$

Molar mass of $N_2O_4 = 92 g\ mol^{-1}$

Molar mass of mixture

$= 2 \times V.D. = 2 \times 38.3 = 76.6$ g/mol

$\Rightarrow \frac{x}{46} + \frac{200 - x}{92} = \frac{200}{76.6}$

$92x + 9200 - 46x = 11049.75$

$46x = 1846.75$ or $x = 40.212$ g

$\therefore$ Number of moles of NO_2 in the mixture

$= \frac{40.212}{46} = 0.874 = 0.874$

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

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

Equivalent mass of $KMnO_4$

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

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

Equivalent mass of

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

$= \frac{\text{molecular mass}}{2}$

$$N_{C_2O_4^{2-}} = 2 \times \text{molarity}$$
$$= 2 \times 10^{-2}$$
$$N_1V_1 = N_2V_2$$
$$5 \times 10^{-4} \times V_1 = 2 \times 10^{-2} \times 0.5$$
$$V_1 = \frac{2 \times 10^{-2} \times 0.5}{5 \times 10^{-4}} = 20\text{L}$$

10 Number of atoms

$$= \frac{\text{Mass}}{\text{Atomic mass}} \times N_A$$

(i) Number of atoms in 560 g Fe

$$= \frac{560}{56} \times N_A = 10N_A$$

(ii) Number of atoms in 70 g N

$$= \frac{70}{14} \times N_A = 5N_A$$

(iii) Number of atoms in 20 g H

$$= \frac{20}{1} \times N_A = 20N_A$$

(iv) Number of atoms in 72 g C

$$= \frac{72}{12} \times N_A = 6N_A$$

(v) Number of atoms in 42 g

$$N = \frac{42}{14} \times N_A = 3N_A$$

$\therefore$ Number of atoms in 560 g Fe

$= 2 \times$ number of atoms in 70 g N

$= \frac{1}{2} \times$ number of atoms in 20 g H

11 22400 mL water contains water molecules $= 6.023 \times 10^{23}$

In 1 mL, the number of water molecules $= \frac{6.023 \times 10^{23}}{22400}$

Since, 1 mL contains 20 drops,

$\therefore$ number of water molecules in

$$1 \text{ drop} = \frac{6.023 \times 10^{23}}{22400 \times 20}$$
$$= 1.344 \times 10^{18} \text{molecules}$$

12 $2Al_2O_3 + 3C \longrightarrow 4Al + 3CO_2$

(C) $\Rightarrow 3 \times 12 = 36$ (Al) $= 4 \times 27 = 108$

$\therefore$ 108 kg of Al required C = 36kg

270 kg of Al required C

$$= \frac{36 \times 270}{108} = 90 \text{ kg}$$

13
$$\underset{\substack{1 \text{ mol} = 100 \text{ g} \\ 0.05 \text{ mol} = 5 \text{ g pure}}}{CaCO_3(s)} \xrightarrow{\Delta} \underset{\substack{1 \text{ mol} = 56 \text{ g} \\ 0.05 \text{ mol} = 2.8 \text{ g}}}{CaO(s)\downarrow} + \underset{\substack{22.4 \text{ L at STP} \\ 1.12 \text{ L at STP}}}{CO_2(g)\uparrow}$$

Impure $CaCO_3$ taken = 10 g

(5g pure $CaCO_3$ + 5 g impurity, as $CaCO_3$ is 50% pure)

(Here, wt. of CO_2 = 2.2 g

so, weight of CaO = 5 − 2.2 = 2.8 g)

CaO(s) left = 2.8 g

Impurity = 5.0 g

Total residue = 7.8 g

14 1L of 0.2M H_2SO_4 contains

= 02 mole of H_2SO_4

1L of 0.2M NaOH contains

= 02 mole of NaOH

According to the given equation, 1 mole of H_2SO_4 reacts with 2 moles of NaOH. Hence, 0.2 mole of NaOH will react with 0.1 mole of H_2SO_4, i.e;NaOH is the limiting reagent. 2 moles of NaOH produce 1 mole of Na_2SO_4. Hence, 0.2 mole of NaOH will produce 0.1 mole of Na_2SO_4

$= 0.1 \times (46 + 32 + 64)$ g $= 0.1 \times 142$g $= 14.2$g

Volume of solution after mixing = 2L

H_2SO_4 left unreacted in the solution

= 0.1 mole

$\therefore$ Molarity of the solution $= \frac{0.1}{2} = 0.05 \text{ molL}^{-1}$

15 Assertion is wrong (false) but Reason is correct (True).

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

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

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