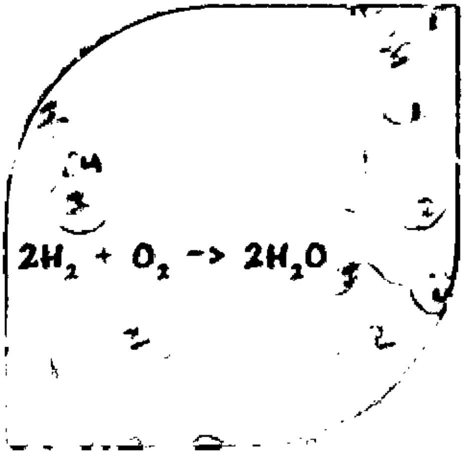


1

STOICHIOMETRY

Laws of Chemical Combination

Chemical reactions take place according to certain laws. These laws are called the Laws of Chemical Combination. "These are no longer useful in chemical calculations now but gives an idea of earlier methods of analysing and relating compounds by mass."

- **Law of Conservation of Mass [Lavoisier (1774)]**

  During any physical or chemical change, the sum of masses of all substances present in reactions vessel remain conserved.

- **Law of Constant Composition or Definite Proportions [Proust (1799)]**

  In a given chemical compound, the elements are always combined in the same proportions by mass.

- **Law of Multiple Proportions [Dalton (1803)]**

  Whenever two elements form more than one compound, the different masses of one element that combine with the same mass of the other element are in the ratio of small whole numbers.

- **Law of Reciprocal Proportions [Richter (1792)]**

  When two elements combine separately with a fixed mass of a third elements then the ratio of their masses in which they do so is either same or some whole number multiple of the ratio in which they combine with each other.

- **Gay-Lussac's Law of combining volumes**

  According to Gay-Lussac's law of combining volume, when gases react together, they always do so in volumes which bear a simple ratio to one another and to the volumes of the products, if these are also gases, provided all measurements of volumes are done under similar conditions of temperature and pressure.

- **Avogadro's Law**

  The volume of a gas (at fixed pressure and temperature) is proportional to the number of moles (or molecules of gas present). Mathematically we can write

  $$V \propto n$$

  Or Equal volumes of all gases under similar conditions of temperature and pressure contain equal number of molecules.

Dalton's Atomic Theory

- Matter consists of tiny particles called atoms.
- Atoms are indestructible. In chemical reactions, the atoms rearrange but they do not themselves break apart.
- In any sample of a pure element, all the atoms are identical in mass and other properties.
- The atoms of different elements different elements differ in mass and other properties.
- When atoms of different elements combine to form compounds, new and more complex particles form. However, in a given compound the constituent atoms are always present in the same fixed numerical ratio.

Modern Atomic Theory

- **Atom is no longer considered to be indivisible :** It has been found that an atom has a complex structure and is composed of sub-atomic particles such as electrons, protons and neutrons.
- **Atoms of the same element may not be similar in all respects :**
  Ex. Isotopes ($^{23}_{11}$Na, $^{24}_{11}$Na)
- **Atoms of different elements may be similar in one or more respects :**
  Ex. Isobars. ($^{40}_{20}$Ca, $^{40}_{18}$Ar)
- **Atom is the smallest unit which takes part in chemical reactions :** Although atom is composed of sub-atomic particles, yet it is the smallest particle which takes part in chemical reactions.
- **The ratio in which atoms unite may be fixed and integral but may not be simple :** For example, in sugar molecule ($C_{12}H_{22}O_{11}$), the ratio of C, H and O atoms is 12 : 22 : 11 which is not simple.
- **Atoms of one element can be changed into atoms of other element :**
  Ex. Artificial Nuclear Reactions
- **The mass of atom can be changed into energy :** According to Einstein's equation $E = mc^2$ (E = Energy, m = mass, c = the velocity of light, *i.e.*, 3×10 cm $\sec^{-1}$), mass and energy are inter-convertible.

Mole Concept

(a) **Definition of one mole :** One mole is a collection of that many entities as there are number of atoms exactly in 12 gm of C-12 isotope.

(b) $1u = 1\text{ amu} = \left(\frac{1}{12}\right)$ of mass of 1 atom of $C^{12} = \frac{1\text{g}}{N_A} = 1.66 \times 10^{-24}$ g

(c) **For Elements :**

- 1 g atom = 1 mole of atoms = N_A atoms.
- g atomic mass (GAM) = mass of N_A atoms in g.
- Mole of atoms = $\frac{\text{Mass }(g)}{\text{GAM of molar mass}}$

(d) For molecules :

- ❖ 1 g molecule = 1 mole of molecule = N_A molecule.
- ❖ g molecular mass (GMM) = mass of N_A molecule in g.
- ❖ Mole of molecule = $\dfrac{\text{Mass }(g)}{\text{GMM or molar mass}}$

(e) For ionic compounds :

- ❖ 1 g formula unit = 1 mole of formula unit = N_A formula unit.
- ❖ g formula mass (GFM) = mass of N_A formula unit in g.
- ❖ Mole of formula unit = $\dfrac{\text{Mass }(g)}{\text{GFM of molar mass}}$

(f) 1 mole of a substance
- Contains 6.022×10^{23} particles
- Weighs as much as molecular weight/atomic ionic/weight in grams.
- If it is a gas, one mole occupies a volume of 22.4 L at 1 atm & 273 K

(g) Average or mean atomic mass : Average atomic mass of element

$$A_{\text{Avg.}} = \frac{A_1x_1 + A_2x_2 + \ldots\ldots}{x_1 + x_2 + \ldots\ldots}$$

Here A_1, A_2 are isotopic mass of element and x_1, x_2 are natural abundance of isotopes.

(h) Average or mean molar mass : The average molar mass of the different substance present in the container $M_{\text{Avg.}} = \dfrac{M_1n_1 + M_2n_2 + \ldots\ldots}{n_1 + n_2 + \ldots\ldots}$

Here M_1, M_2 are molar mass of substances and n_1, n_2 are mole of substances present in the container.

Empirical Formula, Molecular Formula

(a) Empirical formula : Formula depicting constituent atom in their simplest ratio.

Molecular formula : Formula depicting actual number of atoms in one molecule of the compound.

(b) Relation between molecular formula and empirical formula :

$$n = \frac{\text{Molecular mass}}{\text{Empirical Formula mass}}$$

(c) Densities :

- ❖ Density = $\dfrac{\text{Mass}}{\text{Volume}}$, Unit: g/cc
- ❖ Relative density = $\dfrac{\text{Density of any substance}}{\text{Density of reference substance}}$
- ❖ Specific gravity = $\dfrac{\text{Density of any substance}}{\text{Density of water at 4°C}}$
- ❖ Vapour density : Ratio of density of vapour to the density of hydrogen at similar pressure and temperature.

$$\text{Vapour density} = \frac{\text{Density of vapour at some temperature and pressure}}{\text{Density of } H_2 \text{ gas at same temperature and pressure}}$$

$$\text{Vapour density} = \frac{\text{Molecular mass}}{2}$$

Stoichiometry

Stoichiometry pronounced ("stoy – key – om – e – tree") is the calculations of the quantities of reactants and products involved in a chemical reaction. Following methods can be used for solving problems.

(a) Mole Method (Balancing is required)

For Ex. :

$$2KClO_3 \xrightarrow{\Delta} 2KCl + 3O_2$$

$$\frac{\text{Mole of } KClO_3}{2} = \frac{\text{Mole of KCl}}{2} = \frac{\text{Mole of } O_2}{3}$$

(b) Principle of Atom Conservation (P.O.A.C.) method (Balancing is not required)

For Ex. :

$$KClO_3 \xrightarrow{\Delta} KCl + O_2$$

POAC for K : $1 \times$ mole of $KClO_3 = 1 \times$ mole of KCl

POAC for Cl : $1 \times$ mole of $KClO_3 = 1 \times$ mole of KCl

POAC for O : $3 \times$ mole of $KClO_3 = 2 \times$ mole of O_2

Concept of Limiting Reagent

(a) Limiting Reagent : It is very important concept in chemical calculation. It refers to reactant which is present in minimum stoichiometry quantity for a chemical reaction. It is reactant consumed fully in a chemical reaction. So all calculations related to various products or in sequence of reactions are made on the basis of limiting reagent.

(b) Calculation of Limiting Reagent : Divide given moles of each reactant by their stoichiometric coefficient, the one with least ratio is limiting reagent.

Percentage Yield

$$\text{The percentage yield of product} = \frac{\text{Actual yield}}{\text{theoretical maximum yield}} \times 100$$

Concentration Terms

(a) For solutions (homogeneous mixture) :

❖ If the mixture is not homogeneous, then none of them is applicable.

(i) $\%$ by mass $\left(\frac{w}{W}\right) = \frac{\text{Wt. of solute}}{\text{Wt. of solution}} \times 100$

[$X\%$ by mass means 100 gm solution contains X gm solute ; $\therefore$ $(100 - X)$ gm solvent]

(ii) $\% \left(\frac{w}{V}\right) = \frac{\text{Wt. of solute}}{\text{Volume of solution}} \times 100$

[$X\% \left(\frac{w}{V}\right)$ means 100 mL solution contains X gm solute]

(iii) $\%\left(\frac{v}{V}\right) = \frac{\text{Volume of solute}}{\text{Volume of solution}} \times 100$

- For gases % by volume is same as mole %

(iv) Mole % $= \frac{\text{Moles of solute}}{\text{Total moles}} \times 100$

(v) Mole fraction $(X) = \frac{\text{Moles of solute}}{\text{Total moles}}$

(vi) Molarity $(M) = \frac{\text{Moles of solute}}{\text{Volume of solution (in litre)}}$

(vii) Molality $(m) = \frac{\text{Moles of solute}}{\text{Mass of solvent (in kg)}}$

(viii) Parts per million (ppm) $= \frac{\text{Mass of solute}}{\text{Mass of solvent}} \times 10^6 \cong \frac{\text{Mass of solute}}{\text{Mass of solution}} \times 10^6$

(ix) Formality $(F) = \frac{\text{No. of formula unit}}{\text{Volume of solution (in litre)}}$

(b) (i) On adding solvent in a solution (dilution) : Number of mole of solute remains constant

$$M_f V_f = M_i V_i$$

(ii) Mixing of two solutions of same solute

$$M_f V_f = M_1 V_1 + M_2 V_2 + \ldots$$

(c) Volume strength of H_2O_2:

H_2O_2 (aq) solution labelled as 'x V' 'volume H_2O_2 (for *e.g.*, '20 V' H_2O_2), it means x volume of O_2 (in litre) at 1 atm and 273K that can be obtained from 1 litre of such a sample when it decomposes according to

$$H_2O_2 \longrightarrow H_2O + \frac{1}{2}O_2$$

$$\text{Molarity of } H_2O_2 = \frac{\text{Volume strength of } H_2O_2}{11.2}$$

Eudiometry

(For reactions involving gaseous reactants and products)

- Eudiometry or gas analysis involves the calculations based on gaseous reactions or the reactions in which at least two components are gaseous, in which the amounts of gases are represented by their volumes, measured at the same pressure and temperature.
- Gay-Lussac's law of volume combination holds good.
- Problem may be solved directly is terms of volume, in place of mole.

The volume of gases produced is often given by mentioning certain solvent which absorb contain gases.

Solvent	gas (es) absorb
KOH (*aq.*)	CO_2, SO_2, Cl_2
Ammon Cu_2Cl_2	CO
Turpentine oil	O_3
Alkaline pyrogallol	O_2
Water	NH_3, HCl
Anhydrous $CuSO_4/CaCl_2$	H_2O

Redox

(a) Oxidation Number : It is the charge (real or imaginary) which an atom appears to have when it is in combination. It may be a whole no. or fractional. An element may have different values of oxidation number depending . It depends on nature of compound in which it is present. There are some operational rules to determine oxidation number.

(b) Definition of Oxidation and Reduction :

- **Oxidation :** Addition of oxygen , removal of hydrogen , addition of electronegative element, removal of electropositive element , loss of electrons , increase in oxidation number (de-electronation).
- **Reduction :** Removal of oxygen, addition of hydrogen, removal of electronegative element, addition of electropositive element, gain of electrons, decrease in oxid. no. (electronation).
- **Redox Reactions :** A reaction in which oxidation & reduction occur simultaneously.

(c) Agents :

- **Oxidising Agents (Oxidants, Oxidisors) :** They oxidise others, themselves are reduced & gain electrons. *e.g.,* $O_2, O_3, HNO_3, MnO_2, H_2O_2$, halogens, $KMnO_4, K_2Cr_2O_7, KIO_3, Cl(SO_4)_3, FeCl_3$, NaOCl, hydrogen ions.(Atoms present in their higher oxidation state.)
- **Reducing Agents (Reductants or Reducers) :** They reduce others, themselves get oxidised & lose electrons. Also called reductants or reducers . H_2 molecular form is weak reducing agent but Nascent hydrogen is powerful. *e.g.*, C, CO, H_2S, SO_2, $SnCl_2$, Sodium thio Sulphate ($Na_2S_2O_3$), Al, Na, CaH_2, $NaBH_4$, $LiAlH_4$. (Atoms present in their lower oxidation state.)

Both Oxidising & Reducing Agents : SO_2, H_2O_2, O_3, NO_2, etc.

(d) Balancing of redox reactions :

- Ion - electron method
- Oxidation number method

[Concept involved that in any chemical reaction e^- cannot be produced so no. of e^-s in O.H. & R.H. should be same]

Equivalent Concept

(a) Law of Chemical equivalence : It states that in any chemical reaction the equivalents of all the reactants and products must be same.

$$2A + 3B \longrightarrow 4C$$

Equivalents of 'A' = Equivalents of 'B' = Equivalents of 'C'

(b) Terms used in equivalent concept :

- Equivalent mass of $A = \dfrac{\text{Molar mass of } A}{\text{Valency factor or } n \text{ factor}}$
- Equivalents of 'A' $= \dfrac{\text{Weight of '}A\text{' (in g)}}{\text{Equivalent weight of '}A\text{'}}$
- Numbers of equivalents of 'A' = no. of moles of 'A'×n-factor
- **Normality (*N*) :** For solutions concentration term **normality (*N*)** is used, which can be defined as "The number of equivalent of solute present in one litre (1000 mL) solution".

$$N = \frac{\text{Number of equivalents of solute}}{\text{Volume of solution (in L)}}$$

$$N = \frac{W(g) \times 1000}{E \times V \text{ (in mL)}}$$

$$N = \text{Molarity} \times \text{Valence factor}$$

milli-equivalents of solute $= N \times V$ (in mL) $= M \times V$ (in mL) ×n factor

(c) Valence factor (*n*-factor) calculation : *n*-factor here we mean a conversion factor by which we divide molar mass of substance to get equivalent mass and it depends on nature of substance which vary from one condition to another condition. We can divide *n*-factor calculations in two category.

- **In case of non-redox reaction.**

  n-factor = mole of charge displaced per mole of specie

- **In case of redox reaction.**

  n-factor of oxidizing or reducing agent = mole of electrons gain or lost per mol of specie.

(d) Volumetric analysis (Titration) : Titration is a procedure for determining the concentration of a solution by allowing a carefully measured volume to react with a standard solution of another substance, whose concentration is known.

- **Primary standard :** A substance available in a pure form or state of known purity which is used in standardizing a solution.
- **Standardization :** The process by which the concentration of a solution is accurately ascertained.
- **Standard solution :** A solution whose concentration has been accurately determined.
- **Titrant :** The reagent (a standard solution) which is added from a buret to react with the analyte.
- **Titrate :** This mainly involve titrations based chemistry. It can be divided into two major category.

  (I) Non-redox reactions (II) Redox reactions

(e) Type of reactions :

(i) Non-redox reactions : This involve following kind of titrations :

1. Acid-Base titrations
2. Double indicator acid-base titration

3. Precipitation titration
4. Back titration

(ii) Redox reactions : This involve following kind of titrations :

1. Iodimetry titrations
2. Iodometry titrations
3. Back titration

(f) Titrations :

(I) Non-redox titrations

(1) Acid-Base titration : To find out strength or concentration of unknown acid or base it is titrated against base or acid of known strength. At the equivalence point we can know amount of acid or base used and then with the help of law of equivalents we can find strength of unknown.

milliequivalent of acid at equivalence point = milliequivalent of base at equivalence point

(2) Double indicator acid-base titration : In the acid-base titration the equivalence point is known with the help of indicator which changes its colour at the end point. In the titration of polyacidic base or polybasic acid there are more than one end point. Some times one indicator is not able to give colour change at every end point. So to find out each end point we have to use more than one indicator. For example in the titration of Na_2CO_3 against HCl there are two end points.

$$Na_2CO_3 + HCl \longrightarrow NaHCO_3 + NaCl$$
$$NaHCO_3 + HCl \longrightarrow H_2CO_3 + NaCl$$

When we use phenolphthalein in the above titration it changes its colour at first end point when $NaHCO_3$ is formed and with it we can not know second end point. Similarly with methyl orange it changes its colour at second end point only and we can not know first end point. It is because all indicator changes colour on the basis of pH of medium. So in titration of $NaHCO_3$, $KHCO_3$ against acid phenolphthalein can not be used.

Titration	**Indicator**	**pH Range**	***n*-factor**
Na_2CO_3 against acid	Phenolphthalein	8.3 – 10	1
Na_2CO_3	Methyl orange	3.1 – 4.4	2

Note : When we carry out dilution of solution, milliequivalent, equivalent, milli mole or mole of substance does not change because they represent amount of substance, however molar concentration may change.

(3) Precipitation titration : In ionic reaction we can know strength of unknown solution of salt by titrating it against a reagent with which it can form precipitate. For example NaCl strength can be known by titrating it against $AgNO_3$ solution with which it form white ppt. of AgCl.

milliequivalent of NaCl at equivalence point = milliequivalent of $AgNO_3$ used = milliequivalent of AgCl formed

(II) Redox Titrations

At equivalence point,

milliequivalent of Oxidizing agent used = milliequivalent of reducing agent reacted.

S.No.	Reagent	Half Reaction	*n*-factor of reagent
1.	FAS (Mohr's salt) $[FeSO_4(NH_4)_2SO_4 \cdot 6H_2O]$	$Fe^{2+} \rightarrow Fe^{3+} + e^-$	1
2.	MnO_4^- (Permanganate ion) (in acidic medium)	$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$	5
3.	MnO_4^- (in basic medium)	$Mn^{7+} + e^- \rightarrow Mn^{6+}$	1
4.	MnO_4^- (in mild basic or neutral medium)	$Mn^{7+} + e^- \rightarrow Mn^{4+}$	3
5.	$Cr_2O_7^{2-}$ (dichromate ion)	$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$	6
6.	$C_2O_4^{2-}$ (Oxalate ion)	$C_2O_4^{2-} \rightarrow 2CO_2 + 2e^-$	2
7.	As_2O_3	$As_2O_3 + 5H_2O \rightarrow 2AsO_4^{3-} + 10H^+ + 4e^-$	4
8.	$CaOCl_2$ (Bleaching powder)	$CaOCl_2 + H_2O + 2KI \rightarrow Ca(OH)_2 + I_2 + 2KCl$	2
9.	MnO_2	$MnO_2 + 4HCl\,(Conc.) \xrightarrow{\Delta} MnCl_2 + Cl_2 + 2H_2O$	2
10.	IO_3^-	$IO_3^- + 5I^- + 6H^+ \rightarrow 3I_2 + 3H_2O$	5
11.	H_2O_2 (act as oxidizing agent)	$H_2O_2 + 2e^- \rightarrow 2H_2O$	2
12.	H_2O_2 (act as reducing agent)	$H_2O_2 \rightarrow O_2 + 2e^-$	2
13.	H_2O_2 (disproportion)	$H_2O_2 \rightarrow H_2O + 1/2O_2$	1
14.	Cl_2 (disproportion)	$3Cl_2 + 6OH^-$ (strong) $\rightarrow ClO_3^- + 5Cl^- + 3H_2O$	5/3
15.	H_2S (in acidic medium)	$H_2S + I_2 \rightarrow S + 2I^- + 2H^+$	2
16.	Sn^{2+} (in acidic medium)	$Sn^{2+} + I_2 \rightarrow Sn^{4+} + 2I^-$	2
17.	N_2H_4	$N_2H_4 \rightarrow N_2 + 4H^+ + 4e^-$	4
18.	SO_3^{2-} (in acidic medium)	$SO_3^{2-} + H_2O \rightarrow SO_4^{2-} + 2e^- + 2H^+$	2
19.	$Na_2S_2O_3$ (Sodium thiosulphate or Hypo)	$2Na_2S_2O_3 + I_2 \rightarrow Na_2S_4O_6 + 2NaI$	1
20.	I_2	$I_2 + 2e^- \rightarrow 2I^-$	2

(1) Iodimetry Titration : In such titrations iodine solution is used as an oxidant and iodine is directly titrated against a reducing agent. This type of titrations are used for the determination of strength of reducing agents like sulphides, arsenides, thiosulphates etc., by titrating them against a standard solution of iodine.

This type of titration involves free iodine, here iodine solution is treated with known sodium thiosulphate solution.

$$I_2 + 2Na_2S_2O_3 \longrightarrow 2NaI + Na_2S_4O_6$$

Equivalents of I_2 = Equivalents of $Na_2S_2O_3$ used

(2) Iodometry Titration : It is an indirect method of estimation of iodine. In this titration an oxidizing agent is used to liberate from iodine solution and the liberated iodine is treated with a standard solution of a reducing agent added from a burette. Here a neutral or an acidic solution of an oxidizing agent is used and the amount of liberated I_2 is equal to the equivalents of this oxidizing agent.

These titrations are used to determine the concentration of $K_2Cr_2O_7$, $KMnO_4$, $CuSO_4$, Ferric ions, H_2O_2 etc.

These titrations are carried out in following two steps :

- **Step-1 :** Oxidizing agent (X) + KI (excess) $\longrightarrow I_2$ + reduced state of oxidant

  Equivalents of (X) = Equivalents of I_2
- **Step-2 :** Liberated $I_2 + 2Na_2S_2O_3 \longrightarrow 2NaI + Na_2S_4O_6$

  Equivalents of I_2 = Equivalents of $Na_2S_2O_3$ used

(g) Back titration : Back titration is used in volumetric analysis to find out excess of reagent added by titrating it with suitable reagent. It is also used to find out percentage purity of sample.

For example in acid-base titration suppose we have added excess base $[B(OH)_q]$ in acid (H_nA) solution.

To find excess base it is back titrated with another acid (H_mB) of known strength.

Equivalent of base = equivalent of $(H_nA + H_mB)$

$\Rightarrow$ $q \times$ mole of base taken $= n \times$ mole of H_nA reacted $+ m \times$ mole of H_mB reacted

Hardness of Water

(a) Definition of hard water : Hard water is having soluble salts of calcium and magnessium ions.

(b) Degree of hardness : Degree of hardness defined as number of parts by mass of $CaCO_3$ (or its equivalent quantities of other substance) present in million parts of mass of water.

$$\text{Hardness of water} = \left[\frac{\text{Mass of CaCO}_3}{\text{Mass of water}} \times 10^6\right] \text{ppm}$$

Level 1

1. Calculate number of neutrons present in 12×10^{25} atoms of oxygen ($_8O^{17}$) :
(Given: $N_A = 6 \times 10^{23}$)
(a) 1800 (b) 1600 (c) 1800 N_A (d) 3200 N_A

2. If mass of one atom is 3.32×10^{-23}g, then calculate number of nucleons (neutrons and protons) present in 2 atoms of the element :
(a) 40 (b) 20 (c) 10 (d) 40 N_A

3. Calculate number of electrons present in 9.5 g of PO_4^{3-}:
(a) 6 (b) $5N_A$ (c) $0.1N_A$ (d) $4.7N_A$

4. What is the number of moles of O-atom in 126 amu of HNO_3 ?
(a) 2 (b) $\frac{2}{N_A}$ (c) 6 (d) $\frac{6}{N_A}$

5. What is the charge of 96 amu of S^{2-} ?
(a) 2C (b) 3.2×10^{-19}C (c) 9.6×10^{-19}C (d) 6C

6. A sample of sodium has a mass of 46 g. What is the mass of the same number of calcium atoms as sodium atoms present in given sample ?
(a) 46 g (b) 20 g (c) 40 g (d) 80 g

7. The total no. of neutrons present in 54 mL H_2O (l) are:
(a) $3 N_A$ (b) $30 N_A$ (c) $24 N_A$ (d) none of these

8. Total no. of electrons present in 48 g Mg^{2+} are:
(a) $24 N_A$ (b) $2 N_A$ (c) $20 N_A$ (d) none of these

9. The number of neutron in 5 g of D_2O (D is $_1^2H$) are:
(a) $0.25 N_A$ (b) $2 \cdot 5 N_A$ (c) $1 \cdot 1 N_A$ (d) none of these

10. Cisplatin, an anticancer drug, has the molecular formula $Pt(NH_3)_2Cl_2$. What is the mass (in gram) of one molecule ? (Atomic weights : Pt = 195, H = 1.0, N = 14, Cl = 35.5)
(a) 4.98×10^{-21} (b) 4.98×10^{-22} (c) 6.55×10^{-21} (d) 3.85×10^{-22}

11. Aspirin has the formula $C_9H_8O_4$. How many atoms of oxygen are there in a tablet weighing 360 mg?
(a) 1.204×10^{23} (b) 1.08×10^{22} (c) 1.204×10^{24} (d) 4.81×10^{21}

12. 20 g of an ideal gas contains only atoms of S and O occupies 5.6 L at 1 atm and 273 K. What is the mol. wt. of gas ?
(a) 64 (b) 80 (c) 96 (d) None of these

13. A sample of ammonium phosphate, $(NH_4)_3PO_4$, contains 6 moles of hydrogen atoms. The number of moles of oxygen atoms in the sample is:
(a) 1 (b) 2 (c) 4 (d) 6

14. Total number of moles of oxygen atoms in 3 litre $O_3(g)$ at 27°C and 8.21 atm are:
(a) 3 (b) 1 (c) 1 (d) none of these

15. 3.011×10^{22} atoms of an element weight 1.15 gm. The atomic mass of the element is:
(a) 10 (b) 2.3 (c) 35.5 (d) 23

16. One atom of an element x weigh 6.643×10^{-23} g. Number of moles of atom in 20 kg is:
(a) 4 (b) 40 (c) 100 (d) 500

17. Mass of one atom of the element A is 3.9854×10^{-23} g. How many atoms are contained in 1 g of the element A?
(a) 2.509×10^{23} (b) 6.022×10^{23} (c) 12.044×10^{23} (d) None of these

18. Which of the following contains the largest mass of hydrogen atoms?
(a) 5.0 moles $C_2H_2O_4$ (b) 1.1 moles $C_3H_8O_3$
(c) 1.5 moles $C_6H_8O_6$ (d) 4.0 moles $C_2H_4O_2$

19. Which has minimum number of atoms of oxygen ?
(a) 10 mL $H_2O\,(l)$ (b) 0.1 mole of $V_2O_5\,(s)$
(c) 12 gm $O_3(g)$ (d) 12.044×10^{22} molecules of CO_2

20. Rearrange the following (I to IV) in the order of increasing masses:
(I) 0.5 mole of O_3 (II) 0.5 gm atom of oxygen
(III) 3.011×10^{23} molecules of O_2 (IV) 5.6 litre of CO_2 at STP
(a) II < IV < III < I (b) II < I < IV < III (c) IV < II < III < I (d) I < II < III < IV

21. The volume of a drop of water is 0.0018 ml then the number of water molecules present in two drop of water at room temperature is:
(a) 12.046×10^{19} (b) 1.084×10^{18} (c) 4.84×10^{17} (d) 6.023×10^{23}

22. It is known that atom contain protons, neutrons and electrons. If the mass of neutron is assumed to half of its original value whereas that of proton is assumed to be twice of its original value then the atomic mass of ${}^{14}_{6}C$ will be :
(a) same (b) 14.28% less (c) 14.28% more (d) 28.56% less

23. Common salt obtained from sea-water contains 8.775% NaCl by mass. The number of formula units of NaCl present in 25 g of this salt is :
(a) 3.367×10^{23} formula units (b) 2.258×10^{22} formula units
(c) 3.176×10^{23} formula units (d) 4.73×10^{25} formula units

24. The number of hydrogen atoms present in 25.6 g of sucrose ($C_{12}H_{22}O_{11}$) which has a molar mass of 342.3 g is :
(a) 22×10^{23} (b) 9.91×10^{23} (c) 11×10^{23} (d) 44×10^{23}

25. Caffiene has a molecular weight of 194. If it contains 28.9% by mass of nitrogen, number of atoms of nitrogen in one molecule of caffeine is :
(a) 4 (b) 6 (c) 2 (d) 3

26. The density of water is 1g/mL. What is the volume occupied by 1 molecule of water ?
(a) 1.44×10^{-23} mL (b) 1 mL (c) 18 mL (d) 2.88×10^{-23} mL

27. A 25.0 mm × 40.0 mm piece of gold foil is 0.25 mm thick. The density of gold is $19.32\ g/cm^3$. How many gold atoms are in the sheet ? (Atomic weight : Au = 197.0)
(a) 7.7×10^{23} (b) 1.5×10^{23} (c) 4.3×10^{21} (d) 1.47×10^{22}

28. If average molecular wt. of air is 29, then assuming N_2 and O_2 gases are there which options are correct regarding composition of air:
(i) 75% by mass of N_2 (ii) 75% by moles N_2 (iii) 72.41% by mass of N_2
(a) only (i) is correct (b) only (ii) is correct
(c) both (ii) and (iii) are correct (d) both (i) and (ii) are correct

29. Density of dry air containing only N_2 and O_2 is 1.15 g/L at 740 mm and 300 K. What is % composition of N_2 by weight in the air ?
(a) 78% (b) 75.5% (c) 70.02% (d) 72.75%

30. A gaseous mixture of H_2 and CO_2 gas contains 66 mass % of CO_2. The vapour density of the mixture is:
(a) 6.1 (b) 5.4 (c) 2.7 (d) 10.8

31. The vapour density of a mixture containing NO_2 and N_2O_4 is 27.6. The mole fraction of N_2O_4 in the mixture is:
(a) 0.1 (b) 0.2 (c) 0.5 (d) 0.8

32. Density of an ideal gas at 2 atm and 600 K is 2 g/L.
Calculate relative density of this gas with respect to Ne(g) at same conditions :
(Given : $R = 1/12$ atm L/mol.K)
(a) 2.5 (b) 2 (c) 3 (d) 5

33. Average atomic mass of magnesium is 24.31 a.m.u. This magnesium is composed of 79 mole % of ^{24}Mg and remaining 21 mole % of ^{25}Mg and ^{26}Mg. Calculate mole % of ^{26}Mg.
(a) 10 (b) 11 (c) 15 (d) 16

34. Indium (atomic weight = 114.82) has two naturally occurring isotopes, the predominant one form has isotopic weight 114.9041 and abundance of 95.72%. Which of the following isotopic weights is the most likely for the other isotope ?
(a) 112.94 (b) 115.90 (c) 113.90 (d) 114.90

35. Calculate density of a gaseous mixture which consist of 3.01×10^{24} molecules of N_2 and 32 g of O_2 gas at 3 atm pressure and 860 K temperature (Given : $R = 1/12$ atm L/mole.K)
(a) 0.6 g/L (b) 1.2 g/L (c) 0.3 g/L (d) 12 g/L

36. A mixture of O_2 and gas "*Y*" (mol. wt. 80) in the mole ratio $a : b$ has a mean molecular weight 40. What would be mean molecular weight, if the gases are mixed in the ratio $b : a$ under identical conditions ? (gases are non-reacting):
(a) 40 (b) 48 (c) 62 (d) 72

37. If water sample are taken from sea, rivers or lake, they will be found to contain hydrogen and oxygen in the approximate ratio of 1 : 8. This indicates the law of:
(a) Multiple proportion (b) Definite proportion
(c) Reciprocal proportions (d) None of these

38. Hydrogen and oxygen combine to form H_2O_2 and H_2O containing 5.93% and 11.2% hydrogen respectively. The data illustrates :
(a) law of conservation of mass (b) law of constant proportion
(c) law of reciprocal proportion (d) law of multiple proportion

39. One of the following combinations illustrate law of reciprocal proportions :
(a) N_2O_3, N_2O_4, N_2O_5 (b) NaCl, NaBr, NaI
(c) CS_2, CO_2, SO_2 (d) PH_3, P_2O_3, P_2O_5

40. Carbon and oxygen combine to form two oxides, carbon monoxide and carbon dioxide in which the ratio of the weights of carbon and oxygen is respectively 12 : 16 and 12 : 32. These figures illustrate the :
(a) Law of multiple proportions (b) Law of reciprocal proportions
(c) Law of conservation of mass (d) Law of constant proportions

41. A sample of calcium carbonate ($CaCO_3$) has the following percentage composition : Ca = 40%, C = 12%, O = 48%. If the law of constant proportions is true, then the weight of calcium in 4 g of a sample of calcium carbonate obtained from another source will be :
(a) 0.016 g (b) 0.16 g (c) 1.6 g (d) 16 g

42. The law of multiple proportion is illustrated by the two compounds :
(a) Sodium chloride and sodium bromide (b) Ordinary water and heavy water
(c) Caustic soda and caustic potash (d) Sulphur dioxide and sulphur trioxide

43. All the substances listed below are fertilizers that contribute nitrogen to the soil. Which of these is the richest source of nitrogen on a mass percentage basis ?
(a) Urea, $(NH_2)_2CO$ (b) Ammonium nitrate, NH_4NO_3
(c) Nitric oxide, NO (d) Ammonia, NH_3

44. One mole of element *X* has 0.444 times the mass of one mole of element *Y*. One atom of element *X* has 2.96 times the mass of one atom of ^{12}C. What is the atomic weight of *Y* ?
(a) 80 (b) 15.77 (c) 46.67 (d) 40.0

45. A given sample of pure compound contains 9.81 gm of Zn, 1.8×10^{23} atoms of chromium and 0.60 mole of oxygen atoms. What is the simplest formula ?
(a) $ZnCr_2O_7$ (b) $ZnCr_2O_4$ (c) $ZnCrO_4$ (d) $ZnCrO_6$

46. The formula of an acid is HXO_2. The mass of 0.0242 moles of the acid is 1.657 g. What is the atomic weight of *X* ?
(a) 35.5 (b) 28.1 (c) 128 (d) 19.0

47. What is the empirical formula of vanadium oxide, if 2.74 g of the metal oxide contains 1.53 g of metal ?
(a) V_2O_3 (b) VO (c) V_2O_5 (d) V_2O_7

48. Determine the empirical formula of Kelvar, used in making bullet proof vests, is 70.6% C, 4.2% H, 11.8% N and 13.4% O :
(a) $C_7H_5NO_2$ (b) $C_7H_5N_2O$ (c) C_7H_9NO (d) C_7H_5NO

49. The hydrated salt $Na_2CO_3 \cdot xH_2O$ undergoes 63% loss in mass on heating and becomes anhydrous. The value of *x* is:
(a) 10 (b) 12 (c) 8 (d) 18

50. A 6.85 g sample of the hydrate $Sr(OH)_2 \cdot xH_2O$ is dried in an oven to give 3.13 g of anhydrous $Sr(OH)_2$. What is the value of *x* ? (Atomic weights : Sr = 87.60, O = 16.0, H = 1.0)
(a) 8 (b) 12 (c) 10 (d) 6

51. What percentage of oxygen is present in the compound $CaCO_3 \cdot 3Ca_3(PO_4)_2$?
(a) 23.3% (b) 45.36% (c) 41.94% (d) 17.08%

52. Dieldrin, an insecticide, contains C, H, Cl and O. Combustion of 29.72 mg of Dieldrin gave 41.21 mg CO_2 and 5.63 mg of H_2O. In a separate analysis 25.31 mg of Dieldrin was converted into 57.13 mg AgCl. What is the empirical formula of Dieldrin ?
(a) $C_6H_4Cl_3O$ (b) C_8H_8ClO (c) $C_{12}H_8Cl_6O$ (d) $C_6H_4Cl_3O_2$

53. A gaseous compound is composed of 85.7% by mass carbon and 14.3% by mass hydrogen. It's density is 2.28 g/litre at 300 K and 1.0 atm pressure. Determine the molecular formula of the compound :
(a) C_2H_2 (b) C_2H_4 (c) C_4H_8 (d) C_4H_{10}

54. Complete combustion of 0.858 g of compound *X* gives 2.63 g of CO_2 and 1.28 g of H_2O. The lowest molecular mass *X* can have :

(a) 43 g (b) 86 g (c) 129 g (d) 172 g

55. The sulphate of a metal *M* contains 9.87% of *M*. This sulphate is isomorphous with $ZnSO_4 \cdot 7H_2O$. The atomic weight of *M* is :

(a) 40.3 (b) 36.3 (c) 24.3 (d) 11.3

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

(a) $C_6H_8N_2$ (b) $C_7H_{10}N$ (c) $C_5H_6N_3$ (d) $C_4H_{18}N_3$

57. On analysis, a certain compound was found to contain 254 g of iodine (at. mass 127) and 80 g oxygen (at. mass 16). What is the formula of the compound ?

(a) IO (b) I_2O (c) I_5O_3 (d) I_2O_5

58. An element *A* is tetravalent and another element *B* is divalent. The formula of the compound formed from these elements will be :

(a) A_2B (b) AB (c) AB_2 (d) A_2B_3

59. A compound used in making nylon, is 43.8% oxygen. There are four oxygen atoms per molecule. What is the molecular weight of compound?

(a) 36 (b) 116 (c) 292 (d) 146

60. Suppose two elements *X* and *Y* combine to form two compounds XY_2 and X_2Y_3 when 0.05 mole of XY_2 weighs 5 g while 3.011×10^{23} molecules of X_2Y_3 weighs 85 g. The atomic masses of *X* and *Y* are respectively :

(a) 20, 30 (b) 30, 40 (c) 40, 30 (d) 80, 60

61. 44 g of a sample on complete combustion gives 88 gm CO_2 and 36 gm of H_2O. The molecular formula of the compound may be:

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

62. 40 milligram diatomic volatile substance (X_2) is converted to vapour that displaced 4.92 mL of air at 1 atm and 300 K. Atomic weight of element *X* is nearly:

(a) 400 (b) 240 (c) 200 (d) 100

63. Two element *X* (at. mass = 75) and *Y* (at. mass = 16) combine to give a compound having 75.8% of *X*. The formula of the compound is:

(a) XY (b) X_2Y (c) X_2Y_2 (d) X_2Y_3

64. A sample of phosphorus that weighs 12.4 g exerts a pressure 8 atm in a 0.821 litre closed vesel at 527°C. The molecular formula of the phosphorus vapour is:

(a) P_2 (b) P_4 (c) P_6 (d) P_8

65. Manganese forms non-stoichiometric oxides having the general formula MnO_x. The value of x for the compound that analyzed 64% by mass Mn:

(a) 1.16 (b) 1.83 (c) 2 (d) 1.93

66. 1.44 gram of titanium (At. wt. = 48) reacted with excess of O_2 and produce x gram of non-stoichiometric compound $Ti_{1.44}O$. The value of x is:

(a) 2 (b) 1.77 (c) 1.44 (d) none of these

67. Which statement is false for the balanced equation given below ?

$$CS_2 + 3O_2 \longrightarrow 2SO_2 + CO_2$$

(a) One mole of CS_2 will produce one mole of CO_2
(b) The reaction of 16 g of oxygen produces 7.33 g of CO_2
(c) The reaction of one mole of O_2 will produce 2/3 mole of SO_2
(d) Six molecules of oxygen requires three molecules of CS_2

68. Which of the following setups is correct to calculate the weight (in g) of $KClO_3$ produced from the reaction of 0.150 moles of Cl_2?

$$3Cl_2 + 6KOH \longrightarrow 5KCl + KClO_3 + 3H_2O$$

(a) 0.150 moles Cl_2 × 1 mole $KClO_3$/3 moles Cl_2 × 122.5 g/1 mole $KClO_3$
(b) 0.150 moles Cl_2 × 1 mole $KClO_3$/3 moles Cl_2 × 1 mole $KClO_3$/122.5 g
(c) 0.150 moles Cl_2 × 3 moles Cl_2/1 mole $KClO_3$ × 122.5 g/1 mole $KClO_3$
(d) 0.150 moles Cl_2 × 3 moles Cl_2/1 mole $KClO_3$ × 1 mole $KClO_3$/122.5 g

69. 2.0 g sample contain mixture of SiO_2 and Fe_2O_3, on very strong heating leave a residue weighing 1.96 g. The reaction responsible for loss of weight is

$$Fe_2O_3\,(s) \longrightarrow Fe_3O_4\,(s) + O_2\,(g),\ \text{(unbalance equation)}$$

What is the percentage by mass of SiO_2 in original sample ?

(a) 10% (b) 20% (c) 40% (d) 60%

70. What volume of air at 1 atm and 273 K containing 21% of oxygen by volume is required to completely burn sulphur (S_8) present in 200 g of sample, which contains 20% inert material which does not burn. Sulphur burns according to the reaction

$$\frac{1}{8}S_8(s) + O_2(g) \longrightarrow SO_2(g)$$

(a) 23.52 litre (b) 320 litre (c) 112 litre (d) 533.33 litre

71. For the reaction, $2Fe(NO_3)_3 + 3Na_2CO_3 \longrightarrow Fe_2(CO_3)_3 + 6NaNO_3$

Initially if 2.5 mole of $Fe(NO_3)_2$ and 3.6 mole of Na_2CO_3 is taken. If 6.3 mole of $NaNO_3$ is obtained then % yield of given reaction is:

(a) 50 (b) 84 (c) 87.5 (d) 100

72. How many moles of P_4 can be produced by reaction of 0.10 moles $Ca_5(PO_4)_3F$, 0.36 moles SiO_2 and 0.90 moles C according to the following reaction ?

$$4\,Ca_5(PO_4)_3F + 18\,SiO_2 + 30\,C \longrightarrow 3P_4 + 2CaF_2 + 18CaSiO_3 + 30\,CO$$

(a) 0.060 (b) 0.030 (c) 0.045 (d) 0.075

73. Some older emergency oxygen masks containing potassium superoxide, KO_2 which reacts with CO_2 and water in exhaled air to produce oxygen according to the given equation. If a person exhales 0.667 g of CO_2 per minute, how many grams of KO_2 are consumed in 5.0 minutes?

$$4KO_2 + 2H_2O + 4CO_2 \longrightarrow 4KHCO_3 + 3O_2$$

(a) 10.7 (b) 0.0757 (c) 1.07 (d) 5.38

74. The mass of N_2F_4 produced by the reaction of 2.0 g of NH_3 and 8.0 g of F_2 is 3.56 g. What is the per cent yield?

$$2NH_3 + 5F_2 \longrightarrow N_2F_4 + 6HF$$

(a) 79.0 (b) 71.2 (c) 84.6 (d) None of these

75. Calculate the weight of lime (CaO) obtained by heating 200 kg of 95% pure lime stone ($CaCO_3$):

(a) 104.4 kg (b) 105.4 kg (c) 212.8 kg (d) 106.4 kg

76. Phosphoric acid (H_3PO_4) prepared in a two step process.

(1) $P_4 + 5O_2 \longrightarrow P_4O_{10}$ (2) $P_4O_{10} + 6H_2O \longrightarrow 4H_3PO_4$

We allow 62 g of phosphorus to react with excess oxygen which form P_4O_{10} in 85% yield. In the step (2) reaction 90% yield of H_3PO_4 is obtained. Produced mass of H_3PO_4 is:

(a) 37.485 g (b) 149.949 g (c) 125.47 g (d) 564.48 g

77. 9 moles of "*D*" and 14 moles of *E* are allowed to react in a closed vessel according to given reactions. Calculate number of moles of *B* formed in the end of reaction, if 4 moles of *G* are present in reaction vessel. (Percentage yield of reaction is mentioned in the reaction)

Step-1 $3D + 4E \xrightarrow{80\%} 5C + A$

Step-2 $3C + 5G \xrightarrow{50\%} 6B + F$

(a) 2.4 (b) 30 (c) 4.8 (d) 1

78. The chief ore of Zn is the sulphide, ZnS. The ore is concentrated by froth floatation process and then heated in air to convert ZnS to ZnO.

$$2ZnS + 3O_2 \xrightarrow{80\%} 2ZnO + 2SO_2$$

$$ZnO + H_2SO_4 \xrightarrow{100\%} ZnSO_4 + H_2O$$

$$2ZnSO_4 + 2H_2O \xrightarrow{80\%} 2Zn + 2H_2SO_4 + O_2$$

The number of moles of ZnS required for producing 2 moles of Zn will be :

(a) 3.125 (b) 2 (c) 2.125 (d) 4

79. 0.8 mole of a mixture of CO and CO_2 requires exactly 40 gram of NaOH in solution for complete conversion of all the CO_2 into Na_2CO_3. How many moles more of NaOH would it require for conversion into Na_2CO_3, if the mixture (0.8 mole) is completely oxidised to CO_2?

(a) 0.2 (b) 0.6 (c) 1 (d) 1.5

80. Silver oxide (Ag_2O) decomposes at temperature 300°C yielding metallic silver and oxygen gas. A 1.60 g sample of impure silver oxide yields 0.104 g of oxygen gas. What is the per cent by mass of the silver oxide in the sample ?

(a) 5.9 (b) 47.125 (c) 94.25 (d) 88.2

81. 342 gm of 20% by mass of $Ba(OH)_2$ solution (sp. gr. 0.57) is reacted with 1200 mL of 2*M* HNO_3. If the final density is same as pure water then molarity of the ion in resulting solution by nature of the above solution is identified, is:

(a) 0.25 (b) 0.5 *M* (c) 0.888 *M* (d) None of these

82. 100 mL of H_2SO_4 solution having molarity 1 *M* and density 1.5 g/mL is mixed with 400 mL of water. Calculate final molarity of H_2SO_4 solution, if final density is 1.25 g/mL :

(a) 4.4 *M* (b) 0.145 *M* (c) 0.52 *M* (d) 0.227 *M*

83. What volume of HCl solution of density 1.2 g/cm^3 and containing 36.5% by weight HCl, must be allowed to react wtih zinc (Zn) in order to liberate 4.0 g of hydrogen ?

(a) 333.33 mL (b) 500 mL (c) 614.66 mL (d) None of these

84. An ideal gaseous mixture of ethane (C_2H_6) and ethene (C_2H_4) occupies 28 litre at 1 atm and 273 K. The mixture reacts completely with 128 g O_2 to produce CO_2 and H_2O. Mole fraction at C_2H_6 in the mixture is:

(a) 0.6 (b) 0.4 (c) 0.5 (d) 0.8

85. Wood's metal contains 50.0% bismuth, 25.0% lead, 12.5% tin and 12.5% cadmium by weight. What is the mole fraction of tin ?
(Atomic weights : Bi = 209, Pb = 207, Sn = 119, Cd = 112)
(a) 0.202 (b) 0.158 (c) 0.176 (d) 0.221

86. The density of a 56.0% by weight aqueous solution of 1-propanol ($CH_3CH_2CH_2OH$) is 0.8975 g/cm^3. What is the mole fraction of the compound ?
(a) 0.292 (b) 0.227 (c) 0.241 (d) 0.276

87. What is the molartiy of SO_4^{2-} ion in aqueous solution that contain 34.2 ppm of $Al_2(SO_4)_3$? (Assume complete dissociation and density of solution 1 g/mL)
(a) $3 \times 10^{-4}\ M$ (b) $2 \times 10^{-4}\ M$ (c) $10^{-4}\ M$ (d) None of these

88. The relation between molarity (M) and molality (m) is given by :
(ρ = density of solution (mg/mL), M_1 = molecular weight of solute)
(a) $m = \dfrac{1000\,M}{1000\,\rho - M_1}$ (b) $m = \dfrac{1000\,\rho M}{1000\,\rho - MM_1}$
(c) $m = \dfrac{1000\,MM}{1000\,\rho - MM_1}$ (d) $m = \dfrac{1000\,M}{1000\,\rho - MM_1}$

89. Molarity and molality of a solution of an liquid (mol. wt. = 50) in aquous solution is 9 and 10 respectively. What is the density of solution?
(a) 1 g/cc (b) 0.95 g/cc (c) 1.05 g/cc (d) 1.35 g/cc

90. An aqueous solution of ethanol has density 1.025 g/mL and it is 2 M. What is the molality of this solution ?
(a) 1.79 (b) 2.143 (c) 1.951 (d) None of these

91. 0.2 mole of HCl and 0.2 mole of barium chloride were dissolved in water to produce a 500 mL solution. The molarity of the Cl^- ions is :
(a) 0.06 M (b) 0.09 M (c) 1.2 M (d) 0.80 M

92. Calculate the mass of anhydrous HCl in 10 mL of concentrated HCl (density = 1.2 g / mL) solution having 37% HCl by weight.
(a) 4.44 g (b) 4.44 mg (c) 4.44×10^{-3} mg (d) 0.444 μg

93. Calculate the molality of 1 L solution of 80% H_2SO_4 (*w/V*), given that the density of the solution is 1.80 g mL^{-1}.
(a) 8.16 (b) 8.6 (c) 1.02 (d) 10.8

94. Fluoxymesterone, $C_{20}H_{29}FO_3$, is an anabolic steroid. A 500 mL solution is prepared by dissolving 10.0 mg of the steroid in water, 1.0 mL portion of this solution is diluted to a final volume of 1.00 L. What is the resulting molarity ?
(a) 1.19×10^{-10} (b) 1.19×10^{-7} (c) 5.95×10^{-8} (d) 2.38×10^{-11}

95. The lead nitrate, $Pb(NO_3)_2$, in 25 mL of a 0.15 M solution reacts with all of the aluminium sulphate, $Al_2(SO_4)_3$, in 20 mL of solution. What is the molar concentration of the $Al_2(SO_4)_3$?

$$3Pb(NO_3)_2(aq) + Al_2(SO_4)_3(aq) \longrightarrow 3PbSO_4(s) + 2Al(NO_3)_3(aq)$$

(a) $6.25 \times 10^{-2}\ M$ (b) $2.421 \times 10^{-2}\ M$ (c) 0.1875 M (d) None of these

96. Concentrated HNO_3 is 63% HNO_3 by mass and has a density of 1.4 g/mL. How many millilitres of this solution are required to prepare 250 mL of a 1.20 M HNO_3 solution?
(a) 18.0 (b) 21.42 (c) 20.0 (d) 14.21

97. 50 mL of 20.8% (*w/V*) $BaCl_2$ (*aq*) and 100 mL of 9.8% (*w/V*) H_2SO_4 (*aq*) solutions are mixed. Molarity of Cl^- ions in the resulting solution is: (At. wt. of Ba = 137)

(a) 0.333 *M* (b) 0.666 *M* (c) 0.1 *M* (d) 1.33 *M*

98. 100 mL of 10% NaOH (*w/V*) is added to 100 mL of 10% HCl (*w/V*). The resultant solution becomes:

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

99. How many millilitres of 0.1 *M* H_2SO_4 must be added to 50 mL of 0.1 *M* NaOH to give a solution that has a concentration of 0.05 *M* in H_2SO_4 ?

(a) 400 mL (b) 200 mL (c) 100 mL (d) None of these

100. 1 *M* HCl and 2 *M* HCl are mixed in volume ratio of 4 : 1. What is the final molarity of HCl solution?

(a) 1.5 (b) 1 (c) 1.2 (d) 1.8

101. Three solutions *X*, *Y*, *Z* of HCl are mixed to produce 100 mL of 0.1 *M* solution. The molarities of *X*, *Y* and *Z* are 0.07 *M*, 0.12 *M* and 0.15 *M* respectively. What respective volumes of *X*, *Y* and *Z* should be mixed ?

(a) 50 mL, 25 mL, 25 mL (b) 20 mL, 60 mL, 20 mL
(c) 40 mL, 30 mL, 30 mL (d) 55 mL, 20 mL, 25 mL

102. A bottle of an aqueous H_2O_2 solution is labelled as '28 *V*' H_2O_2 and the density of the solution (in g/mL) is 1.25. Choose the correct option:

(a) Molality of H_2O_2 solution is 2 (b) Molarity of H_2O_2 solution is 5
(c) Molality of H_2O_2 solution is 2.15 (d) None of these

103. The impure 6 g of NaCl is dissolved in water and then treated with excess of silver nitrate solution. The weight of precipitate of silver chloride is found to be 14 g. The % purity of NaCl solution would be:

(a) 95% (b) 85% (c) 75% (d) 65%

104. $Al_2(SO_4)_3$ solution of 1 molal concentration is present in 1 litre solution of 2.684 g/cc. How many moles of $BaSO_4$ would be precipitated on adding $BaCl_2$ in excess ?

(a) 2 moles (b) 3 moles (c) 6 moles (d) 12 moles

105. A certain public water supply contains 0.10 ppb (part per billion) of chloroform ($CHCl_3$). How many molecules of $CHCl_3$ would be obtained in 0.478 mL drop of this water ?
(assumed $d = 1$ g/mL)

(a) $4 \times 10^{-3} \times N_A$ (b) $10^{-3} \times N_A$ (c) $4 \times 10^{-10} \times N_A$ (d) None of these

106. Decreasing order (first having highest and then others following it) of mass of pure NaOH in each of the aqueous solution:

(i) 50 g of 40% (*w/W*) NaOH
(ii) 50 mL of 50% (*w/V*) NaOH $[d_{soln.} = 1.2\,g/mL]$
(iii) 50 g of 15 *M* NaOH $[d_{soln.} = 1\,g/mL]$

(a) i, ii, iii (b) iii, ii, i (c) ii, iii, i (d) ii, i, iii

107. What is the molar mass of diacidic organic Lewis base (*B*), if 12 g of chloroplatinate salt (BH_2PtCl_6) on ignition produced 5 gm residue of Pt?

(a) 52 (b) 58 (c) 88 (d) None of these

108. One gram of the silver salt of an organic dibasic acid yields, on strong heating, 0.5934 g of silver. If the weight percentage of carbon in it 8 times the weight percentage of hydrogen and one-half the weight percentage of oxygen, determine the molecular formula of the acid.

(a) $C_4H_6O_4$ (b) $C_4H_6O_6$ (c) $C_2H_6O_2$ (d) $C_5H_{10}O_5$

109. 0.607 g of a silver salt of tribasic organic acid was quantitatively reduced to 0.37 g of pure Ag. What is the mol. wt. of the acid?

(a) 207 (b) 210 (c) 531 (d) 324

110. A sample of peanut oil weighing 2 g is added to 25 mL of 0.40 *M* KOH. After saponification is complete, 8.5 mL of 0.28 *M* H_2SO_4 is needed to neutralize excess of KOH. The saponification number of peanut oil is :

(saponification number is defined as the milligrams of KOH consumed by 1 g of oil)

(a) 146.72 (b) 223.44 (c) 98.9 (d) None of these

111. 20 mL of a mixture of CO and H_2 were mixed with excess of O_2 and exploded and cooled. There was a volume contraction of 18 mL. All volume measurements corresponds to room temperature (27°C) and one atmospheric pressure. Determine the volume ratio $V_1 : V_2$ of CO and H_2 in the original mixture.

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

112. In the reaction,

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

(a) 6 L HCl(*aq*) is consumed for every 3 L $H_2(g)$ 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 1 atm and 273 K is produced for every mole Al that reacts

(d) 11.2 L $H_2(g)$ at 1 atm and 273 K is produced for every mole HCl(*aq*) consumed

113. The percentage by volume of C_3H_8 in a gaseous mixture of C_3H_8, CH_4 and CO is 20. When 100 mL of the mixture is burnt in excess of O_2, the volume of CO_2 produced is:

(a) 90 mL (b) 160 mL (c) 140 mL (d) none of these

114. 40 mL gaseous mixture of CO, CH_4 and Ne was exploded with 10 mL of oxygen. On cooling, the gases occupied 36.5 mL. After treatment with KOH the volume reduced by 9 mL and again on treatment with alkaline pyrogallol, the volume further reduced.

Percentage of CH_4 in the original mixture is:

(a) 22.5 (b) 77.5 (c) 7.5 (d) 15

115. A gaseous mixture of propane and butane of volume 3 litre on complete combustion produces 11.0 litre CO_2 under standard conditions of temperature and pressure.

The ratio of volume of butane to propane is:

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

116. Phosphorous has the oxidation state of +1 in:

(a) Orthophosphoric acid (b) Phosphorous acid

(c) Hypophosphorous acid (d) Metaphosphoric acid

117. The oxidation state(s) of Cl in $CaOCl_2$ (bleaching powder) is/are:

(a) +1 only (b) −1 only (c) +1 and −1 (d) none of these

118. The oxidation number of sulphur in S_8, S_2F_2, H_2S and H_2SO_4 respectively are:

(a) 0, + 1, − 2 and 6 (b) + 2, 0, + 2 and 6

(c) 0, + 1, + 2 and 4 (d) − 2, 0, + 2 and 6

119. Fe shows an oxidation state of +1 in:
(a) $Fe(CO)_5$ (b) $[Fe(H_2O)_5NO]\,SO_4$
(c) $Fe_4[Fe(CN)_6]_3$ (d) $FeCl_4^-$

120. When SO_2 is passed into an acidified potassium dichromate solution, the oxidation numbers of sulphur and chromium in the final products respectively are:
(a) +6, +6 (b) +6, +3 (c) 0, +3 (d) +2, +3

121. The oxidation number of nitrogen atoms in NH_4NO_3 are:
(a) +3, +3 (b) +3, − 3 (c) − 3, + 5 (d) −5, + 3

122. The oxidation states of S-atoms in Caro's and Marshell's acids are:
(a) + 6, + 6 (b) + 6, + 4 (c) + 6, − 6 (d) + 4, + 6

123. In which of the following the oxidation number of oxygen has been arranged in increasing order :
(a) $OF_2 < KO_2 < BaO_2 < O_3$ (b) $BaO_2 < KO_2 < O_3 < OF_2$
(c) $BaO_2 < O_3 < OF_2 < KO_2$ (d) $KO_2 < OF_2 < O_3 < BaO_2$

124. The oxidation number of oxygen in KO_3, Na_2O_2 is :
(a) 3, 2 (b) 1, 0 (c) 0, 1 (d) –0.33, –1

125. The oxidation number of phosphorus in $Ba(H_2PO_2)_2$ is :
(a) –1 (b) +1 (c) +2 (d) +3

126. If it is known that in $Fe_{0.96}O$, Fe is present in +2 and +3 oxidation state. What is the mole fraction of Fe^{2+} in the compound ?
(a) 12/25 (b) 25/12 (c) 1/12 (d) 11/12

127. Which ordering of compounds is according to the decreasing order of the oxidation state of nitrogen ?
(a) HNO_3, NO, NH_4Cl, N_2 (b) HNO_3, NO, N_2, NH_4Cl
(c) HNO_3, NH_4Cl, NO, N_2 (d) NO, HNO_3, NH_4Cl, N_2

128. 2 mole of N_2H_4 loses 16 mole of electron is being converted to a new compound *X*. Assuming that all of the N appears in the new compound. What is the oxidation state of 'N' in *X* ?
(a) − 1 (b) − 2 (c) + 2 (d) + 4

129. When $K_2Cr_2O_7$ is converted to K_2CrO_4, the change in the oxidation state of chromium is :
(a) 0 (b) 6 (c) 4 (d) 3

130. When a manganous salt is fused with a mixture of KNO_3 and solid NaOH, the oxidation number of Mn changes from +2 to :
(a) +4 (b) +3 (c) +6 (d) +7

131. In Fe(II)–MnO_4^- titration, HNO_3, is not used because:
(a) it oxidises Mn^{2+} (b) it reduces MnO_4^-
(c) it oxidises Fe^{2+} (d) it reduces Fe^{3+} formed

132. Which species are oxidized and reduced in the reaction ?
$FeC_2O_4 + KMnO_4 \longrightarrow Fe^{3+} + CO_2 + Mn^{2+}$
(a) Oxidised : Fe, C ; Reduced : Mn (b) Oxidised : Fe ; Reduced : Mn
(c) Reduced : Fe, Mn ; Oxidised : C (d) Reduced : C ; Oxidised : Mn, Fe

133. In which of the following reactions, H_2O_2 is acting as a reducing agent ?
(a) $SO_2 + H_2O_2 \longrightarrow H_2SO_4$ (b) $2KI + H_2O_2 \longrightarrow 2KOH + I_2$
(c) $PbS + 4H_2O_2 \longrightarrow PbSO_4 + 4H_2O$ (d) $Ag_2O + H_2O_2 \longrightarrow 2Ag + H_2O + O_2$

134. Following reaction describes the rusting of iron

$$4Fe + 3O_2 \longrightarrow 4Fe^{3+} + 6O^{2-}$$

Which one of the following statement is incorrect ?
(a) This is an example of a redox reaction (b) Metallic iron is reduced to Fe^{3+}
(c) Fe^{3+} is an oxidising agent (d) Metallic iron is a reducing agent

135. Which reaction does not represent auto redox or disproportionation ?
(a) $Cl_2 + OH^- \longrightarrow Cl^- + ClO_3^- + H_2O$ (b) $2H_2O_2 \longrightarrow H_2O + O_2$
(c) $2Cu^+ \longrightarrow Cu^{2+} + Cu$ (d) $(NH_4)_2Cr_2O_7 \longrightarrow N_2 + Cr_2O_3 + 4H_2O$

136. Which of the following is redox reaction ?
(a) H_2SO_4 with NaOH
(b) In atmosphere, O_3 from O_2 by lightning
(c) Evaporation of H_2O
(d) Oxides of nitrogen form nitrogen & oxygen by lightning

137. Which of the following is a redox-reaction ?
(a) $2Na[Ag(CN)_2] + Zn \longrightarrow Na_2[Zn(CN)_4] + 2Ag$
(b) $BaO_2 + H_2SO_4 \longrightarrow BaSO_4 + H_2O_2$
(c) $N_2O_5 + H_2O \longrightarrow 2HNO_3$
(d) $AgNO_3 + KI \longrightarrow AgI + KNO_3$

138. For the redox reaction, $MnO_4^- + C_2O_4^{2-} + H^+ \longrightarrow Mn^{2+} + CO_2 + H_2O$
the correct coefficients of the reactants for the balanced reaction are respectively $MnO_4^-, C_2O_4^-, H^+$:
(a) 2, 5, 16 (b) 16, 3, 12 (c) 15, 16, 12 (d) 2, 16, 5

139. In a chemical reaction, $K_2Cr_2O_7 + xH_2SO_4 + ySO_2 \longrightarrow K_2SO_4 + Cr_2(SO_4)_3 + zH_2O$; the value of x, y and z respectively are :
(a) $x = 1, y = 3, z = 1$ (b) $x = 4, y = 1, z = 4$
(c) $x = 3, y = 2, z = 1$ (d) $x = 2, y = 2, z = 1$

140. Balance the following equation and choose the quantity which is the sum of the coefficients of the products :

$$......CS_2 + ...Cl_2 \longrightarrow CCl_4 + ...S_2Cl_2$$

(a) 5 (b) 3 (c) 6 (d) 2

141. Balance the following equation and choose the quantity which is the sum of the coefficients of reactants and products:

$$....PtCl_4 + ...XeF_2 \longrightarrow PtF_6 + ...ClF + ...Xe$$

(a) 16 (b) 13 (c) 18 (d) 12

142. 0.1 mole H_3PO_x is completely neutralised by 5.6 g KOH then the true statement is:
(a) $x = 3$ and given acid is dibasic
(b) $x = 4$ and given acid has no P–H linkage
(c) $x = 2$ and given acid does not form acid salt
(d) all of these

143. When potassium permanganate is titrated against ferrous ammonium sulphate in acidic medium, the equivalent weight of potassium permanganate is:

(a) $\frac{\text{molecular weight}}{3}$ (b) $\frac{\text{molecular weight}}{5}$

(c) $\frac{\text{molecular weight}}{2}$ (d) $\frac{\text{molecular weight}}{10}$

144. Equivalent weight of FeS_2 in the half reaction, $FeS_2 \longrightarrow Fe_2O_3 + SO_2$ is :

(a) $M/10$ (b) $M/11$ (c) $M/6$ (d) $M/1$

145. The equivalent weight of HCl in the given reaction is:

$K_2Cr_2O_7 + 14HCl \longrightarrow 2KCl + 2CrCl_3 + 3Cl_2 + H_2O$

(a) 16.25 (b) 36.5 (c) 73 (d) 85.1

146. Equivalent weight of H_3PO_2 when it disproportionate into PH_3 and H_3PO_3 is:

(a) M (b) $M/2$ (c) $M/4$ (d) $3M/4$

147. In the following reaction, $As_2S_3 + H^+ + NO_3^- \longrightarrow NO + H_2O + AsO_4^{3-} + SO_4^{2-}$

the equivalent weight of As_2S_3 is related to its molecular weight by :

(a) $M/2$ (b) $M/4$ (c) $M/24$ (d) $M/28$

148. Sulphur forms the chlorides S_2Cl_2 and SCl_2. The equivalent mass of sulphur in SCl_2 is :

(a) 8 g/mol (b) 16 g/mol (c) 64.8 g/mol (d) 32 g/mol

149. The equivalent weight of an element is 4. Its chloride has a vapour density 59.25. Then, the valency of the elements is :

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

150. 6×10^{-3} mole $K_2Cr_2O_7$ reacts completely with 9×10^{-3} mole X^{n+} to give XO_3^- and Cr^{3+}. The value of n is :

(a) 1 (b) 2 (c) 3 (d) None of these

151. What weight of $H_2C_2O_4 \cdot 2H_2O$ (mol. wt. = 126) should be dissolved in water to prepare 250 mL of centinormal solution which act as a reducing agent ?

(a) 0.63 g (b) 0.1575 g (c) 0.126 g (d) 0.875 g

152. The equivalent wt. of the salt, $KHC_2O_4 \cdot H_2C_2O_4 \cdot 4H_2O$ when it act as reducing agent is :

(a) $\frac{\text{Mol. wt}}{1}$ (b) $\frac{\text{Mol. wt}}{2}$ (c) $\frac{\text{Mol. wt}}{3}$ (d) $\frac{\text{Mol. wt}}{4}$

153. The equivalent weight of divalent metal is W. The molecular weight of its chloride is :

(a) W + 35.5 (b) W + 71 (c) 2W + 71 (d) 2W + 35.5

154. When BrO_3^- ion reacts with Br^- in acid medium, Br_2 is liberated. The equivalent weight of Br_2 in this reaction is:

(a) $\frac{5M}{8}$ (b) $\frac{5M}{3}$ (c) $\frac{3M}{5}$ (d) $\frac{4M}{6}$

155. If m_A gram of a metal A displaces m_B gram of another metal B from its salt solution and if the equivalent weights are E_A and E_B respectively then equivalent weight of A can be expressed as:

(a) $E_A = \frac{m_A}{m_B} \times E_B$ (b) $E_A = \frac{m_A \times m_B}{E_B}$ (c) $E_A = \frac{m_B}{m_A} \times E_B$ (d) $E_A = \sqrt{\frac{m_A}{m_B} \times E_B}$

156. Hydrazine reacts with KIO_3 in presence of HCl as

$$N_2H_4 + IO_3^- + 2H^+ + Cl^- \longrightarrow ICl + N_2 + 3H_2O$$

The equivalent masses of N_2H_4 and KIO_3 respectively are:

(a) 8 and 53.5 (b) 16 and 53.5 (c) 8 and 35.6 (d) 8 and 87

157. What will be the normality of a solution obtained by mixing 0.45 *N* and 0.60 *N* NaOH in the ratio 2 : 1 by volume ?

(a) 0.4 *N* (b) 0.5 *N* (c) 1.05 *N* (d) 0.15 *N*

158. A solution containing 2.7×10^{-3} mol of A^{2+} ions required 1.6×10^{-3} mole of MnO_4^- for the oxidation of A^{2+} to AO_3^- the medium used is :

(a) neutral (b) acidic (c) strong basic (d) none of these

159. H_2O_2 is used as bleaching reagent because on dissociation it gives oxygen $(H_2O_2 \longrightarrow H_2O + \frac{1}{2}O_2)$.

If "Chachi 420" used H_2O_2 solution to bleach her hair & she required 2.24 L O_2 gas at 1 atm and 273 K. She has a H_2O_2 solution labelled as '5.6 V' then what volume of such solution must she required to bleach her hair ?

(a) 200 mL (b) 300 mL (c) 400 mL (d) 500 mL

160. 1.25 g of a solid dibasic acid is completely neutralised by 25 mL of 0.25 molar $Ba(OH)_2$ solution. Molecular mass of the acid is :

(a) 100 (b) 150 (c) 120 (d) 200

161. 10 mL of *N*-HCl, 20 mL of *N*/2 H_2SO_4 and 30 mL of *N*/3 HNO_3 are mixed together and volume made to one litre. The normality of H^+ in the resulting solution is :

(a) 3*N*/100 (b) *N*/10 (c) *N*/20 (d) *N*/40

162. 0.45 g of an acid of mol. wt. 90 was neutralised by 20 mL of 0.54 *N* caustic potash (KOH). The basicity of acid is :

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

163. A 3.4 g sample of H_2O_2 solution containing x% H_2O_2 by mass requires x mL of a $KMnO_4$ solution for complete oxidation under acidic condition. The molarity of $KMnO_4$ solution is :

(a) 1 (b) 0.5 (c) 0.4 (d) 0.2

164. What volume of $O_2(g)$ measured at 1 atm and 273 K will be formed by action of 100 mL of 0.5 *N* $KMnO_4$ on hydrogen peroxide in an acid solution ? The skeleton equation for the reaction is

$$KMnO_4 + H_2SO_4 + H_2O_2 \longrightarrow K_2SO_4 + MnSO_4 + O_2 + H_2O$$

(a) 0.12 litre (b) 0.028 litre (c) 0.56 litre (d) 1.12 litre

165. A sample of 1.0 g of solid Fe_2O_3 of 80% purity is dissolved in a moderately concentrated HCl solution which is reduced by zinc dust. The resulting solution required 16.7 mL of a 0.1 *M* solution of the oxidant. Calculate the number of electrons taken up by the oxidant.

(a) 2 (b) 4 (c) 6 (d) 5

166. $KMnO_4$ reacts with oxalic acid according to the equation

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

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

(a) 120 mL of 0.25 *M* $H_2C_2O_4$ (b) 150 mL of 0.10 *M* $H_2C_2O_4$

(c) 25 mL of 0.20 *M* $H_2C_2O_4$ (d) 50 mL of 0.20 *M* $H_2C_2O_4$

167. Ratio of moles of Fe (II) oxidised by equal volumes of equimolar $KMnO_4$ and $K_2Cr_2O_7$ solutions in acidic medium will be:
(a) 5 : 3 (b) 1 : 1 (c) 1 : 2 (d) 5 : 6

168. The weight of a mixture containing HCl and H_2SO_4 is 0.1 g. On treatment with an excess of an $AgNO_3$ solution, reacted with this acid mixture gives 0.1435 g of AgCl. Weight % of the H_2SO_4 is mixture is :
(a) 36.5 (b) 63.5 (c) 50 (d) None of these

169. A solution of $Na_2S_2O_3$ is standardized iodometrically against 0.167 g of $KBrO_3$. This process requires 50 mL of the $Na_2S_2O_3$ solution. What is the normality of the $Na_2S_2O_3$?
(a) 0.2 *N* (b) 0.12 *N* (c) 0.72 *N* (d) 0.02 *N*

170. 0.80 g of impure $(NH_4)_2SO_4$ was boiled with 100 mL of a 0.2 *N* NaOH solution till all the $NH_3(g)$ evolved. The remaining solution was diluted to 250 mL. 25 mL of this solution was neutralized using 5 mL of a 0.2 *N* H_2SO_4 solution. The percentage purity of the $(NH_4)_2SO_4$ sample is:
(a) 82.5 (b) 72.5 (c) 62.5 (d) 17.5

171. The NH_3 evolved due to complete conversion of N from 1.12 g sample of protein was absorbed in 45 mL of 0.4 *N* HNO_3. The excess acid required 20 mL of 0.1 *N* NaOH. The % N in the sample is:
(a) 8 (b) 16 (c) 20 (d) 25

172. Find out % of oxalate ion in a given sample of an alkali metal oxalate salt, 0.30 g of it is dissolved in 100 mL water required 90 mL of centimolar $KMnO_4$ solution in acidic medium.
(a) 66% (b) 55% (c) 44% (d) 6.6%

173. 320 mg of a sample of magnesium having a coating of its oxide required 20 mL of 0.1 *M* hydrochloric acid for the complete neutralisation of the latter. The composition of the sample is:
(a) 87.5% Mg and 12.5% MgO (b) 12.5% Mg and 87.5% MgO
(c) 80% Mg and 20% MgO (d) 20% Mg and 80% MgO

174. The concentration of bivalent lead ions in a sample of polluted water that also contains nitrate ions is determined by adding solid sodium sulphate ($M = 142$) to exactly 500 mL water. Calculate the molarity of lead ions if 0.355 g of sodium sulphate was needed for complete precipitation of lead ions as sulphate.
(a) 1.25×10^{-3} *M* (b) 2.5×10^{-3} *M* (c) 5×10^{-3} *M* (d) None of these

175. What volume of HNO_3 (sp. gravity 1.05 g mL^{-1} containing 12.6 (*w/W*) of HNO_3) that reduce into NO is required to oxidise iron 1 g $FeSO_4 \cdot 7H_2O$ in acid medium is:
(a) 70 mL (b) 0.57 mL (c) 80 mL (d) 0.65 mL

176. The total volume of 0.1 *M* $KMnO_4$ solution that are needed to oxidize 100 mg each of ferrous oxalate and ferrous sulphate in a mixture in acidic medium is:
(a) 1.096 mL (b) 1.32 mL (c) 5.48 mL (d) none of these

177. When 2.5 g of a sample of Mohr's salt reacts completely with 50 mL of $\frac{N}{10}$ $KMnO_4$ solution. The % purity of the sample of Mohr's salt is :
(a) 78.4 (b) 70 (c) 37 (d) 40

178. 4 mole of a mixture of Mohr's salt and $Fe_2(SO_4)_3$ requires 500 mL of 1 *M* $K_2Cr_2O_7$ for complete oxidation in acidic medium. The mole % of the Mohr's salt in the mixture is:
(a) 25 (b) 50 (c) 60 (d) 75

179. The equivalent weight of a metal is double than of oxygen. How many times is the equivalent weight of it's oxide than the equivalent weight of the metal ?
(a) 1.5 (b) 2 (c) 3 (d) 4

180. A metal oxide has the formula X_2O_3. It can be reduced by hydrogen to give free metal and water. 0.1596 g of metal oxide requires 6 mg of hydrogen for complete reduction. The atomic weight of the metal (in amu) is:
(a) 15.58 (b) 155.8 (c) 5.58 (d) 55.8

181. Calculate the mass of anhydrous oxalic acid, which can be oxidised to $CO_2(g)$ by 100 mL of an MnO_4^- solution, 10 mL of which is capable of oxidising 50 mL of $1N\ I^-$ to I_2.
(a) 45 g (b) 22.5 g (c) 30 g (d) 12.25 g

182. A mixture of $NaHC_2O_4$ and $KHC_2O_4 \cdot H_2C_2O_4$ required equal volumes of 0.2 N $KMnO_4$ and 0.12 N NaOH separately. What is the molar ratio of $NaHC_2O_4$ and $KHC_2O_4 \cdot H_2C_2O_4$ in the mixture ?
(a) 6 : 1 (b) 1 : 6 (c) 1 : 3 (d) 3 : 1

183. Stannous sulphate ($SnSO_4$) and potassium permanganate are used as oxidising agents in acidic medium for oxidation of ferrous ammonium sulphate to ferric sulphate. The ratio of number of moles of stannous sulphate required per mole of ferrous ammonium sulphate to the number of moles of $KMnO_4$ required per mole of ferrous ammonium sulphate, is :
(a) 2.5 (b) 0.2 (c) 0.4 (d) 2.0

184. If a g is the mass of $NaHC_2O_4$ required to neutralize 100 mL of 0.2 M NaOH and b g that required to reduce 100 mL of 0.02 M $KMnO_4$ in acidic medium, then:
(a) $a = b$ (b) $2a = b$ (c) $a = 2b$ (d) None of these

185. 2 mole, equimolar mixture of $Na_2C_2O_4$ and $H_2C_2O_4$ required V_1 L of 0.1 M $KMnO_4$ in acidic medium for complete oxidation. The same amount of the mixture required V_2 L of 0.2 M NaOH for neutralization. The ratio of V_1 to V_2 is:
(a) 1 : 2 (b) 2 : 1 (c) 4 : 5 (d) 5 : 4

186. A mixture containing 0.05 mole of $K_2Cr_2O_7$ and 0.02 mole of $KMnO_4$ was treated with excess of KI in acidic medium. The liberated iodine required 1.0 L of $Na_2S_2O_3$ solution for titration. Concentration of $Na_2S_2O_3$ solution was:
(a) 0.40 mol L^{-1} (b) 0.20 mol L^{-1} (c) 0.25 mol L^{-1} (d) 0.30 mol L^{-1}

187. 25 mL of 2 N HCl, 50 mL of 4 N HNO_3 and x mL of 2 M H_2SO_4 are mixed together and the total volume is made up to 1 L after dilution. 50 mL of this acid mixture completely reacted with 25 mL of a 1 N Na_2CO_3 solution. The value of x is:
(a) 250 mL (b) 62.5 mL (c) 100 mL (d) None of these

188. In an iodometric estimation, the following reactions occur

$$2Cu^{2+} + 4I^- \longrightarrow Cu_2I_2 + I_2; \quad I_2 + 2Na_2S_2O_3 \longrightarrow 2NaI + Na_2S_4O_6$$

0.12 mole of $CuSO_4$ was added to excess of KI solution and the liberated iodine required 120 mL of hypo. The molarity of hypo solution was:
(a) 2 (b) 0.20 (c) 0.1 (d) 1.0

189. 1 g mixture of equal number of mole of Li_2CO_3 and other metal carbonate (M_2CO_3) required 21.6 mL of 0.5 N HCl for complete neutralisation reaction. What is the approximate atomic weight of the other metal ?
(a) 25 (b) 23 (c) 24 (d) 51

190. 32 g of a sample of $FeSO_4 \cdot 7H_2O$ were dissolved in dilute sulphuric acid and water and it's volume was made up to 1 litre, 25 mL of this solution required 20 mL of 0.02 M $KMnO_4$ solution for complete oxidation. Calculate the weight % of $FeSO_4 \cdot 7H_2O$ in the sample.
(a) 34.75 (b) 69.5 (c) 89.5 (d) None of these

191. In the mixture of ($NaHCO_3 + Na_2CO_3$), volume of HCl required is x mL with phenolphthalein indicator and y mL with methyl orange indicator in the same titration. Hence, volume of HCl for complete reaction of Na_2CO_3 is:
(a) $2x$ (b) y (c) $x/2$ (d) $(y - x)$

192. 0.1 g of a solution containing Na_2CO_3 and $NaHCO_3$ requires 10 mL of 0.01 N HCl for neutralization using phenolphthalein as an indicator. wt. % of Na_2CO_3 in solutions is:
(a) 25 (b) 32 (c) 50 (d) None of these

193. A mixture of NaOH and Na_2CO_3 required 25 mL of 0.1 M HCl using phenolphthalein as the indicator. However, the same amount of the mixture required 30 mL of 0.1 M HCl when methyl orange was used as the indicator. The molar ratio of NaOH and Na_2CO_3 in the mixture was:
(a) 2 : 1 (b) 1 : 2 (c) 4 : 1 (d) 1 : 4

194. 100 mL solution of NaOH and Na_2CO_3 was first titrated with $N/10$ HCl in presence of HPh, 17.5 mL is required to end point. After this MeOH was added and 2.5 mL of same HCl is required. The amount of NaOH in mixture is :
(a) 0.06 g per 100 mL (b) 0.06 g per 200 mL
(c) 0.05 g per 100 mL (d) 0.012 g per 200 mL

195. 1 gram of a sample of $CaCO_3$ was strongly heated and the CO_2 liberated was absorbed in 100 mL of 0.5 M NaOH solution. Assuming 90% purity for the sample. How many mL of 0.5 M HCl would be required to react with the resulting solution to reach the end point in presence of phenolphthalein?
(a) 73 mL (b) 41 mL (c) 82 mL (d) 100 mL

196. A sample of pure sodium carbonate 0.318 g is dissolved in water and titrated with HCl solution. A volume of 60 mL is required to reach the methyl orange end point. Calculate the molarity of the acid.
(a) 0.1 M (b) 0.2 M (c) 0.4 M (d) None of these

197. 10 L of hard water required 5.6 g of lime for removing hardness. Hence temporary hardness in ppm of $CaCO_3$ is:
(a) 1000 (b) 2000 (c) 100 (d) 1

198. 1 L of pond water contains 20 mg of Ca^{2+} and 12 mg of Mg^{2+} ions. What is the volume of a 2 N Na_2CO_3 solution required to soften 5000 L of pond water?
(a) 500 L (b) 50 L (c) 5 L (d) None of these

199. One litre of a sample of hard water contain 4.44 mg $CaCl_2$ and 1.9 mg of $MgCl_2$. What is the total hardness in terms of ppm of $CaCO_3$?

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

200. If hardness of water sample is 200 ppm, then select the incorrect statement :

(a) Mass ratio of $CaCO_3$ to H_2O is $\frac{0.02}{100}$

(b) Mol ratio of $CaCO_3$ to H_2O is 3.6×10^{-5}

(c) Mass of $CaCO_3$ present in hard water is 0.2 g/L

(d) 1 miliequivalent of $CaCO_3$ present in 1 kg of hard water

Level 2

1. A mixture of NH_4NO_3 and $(NH_4)_2HPO_4$ contain 30.40% mass per cent of nitrogen. What is the mass ratio of the two components in the mixture ?
(a) 2 : 1 (b) 1 : 2 (c) 3 : 4 (d) 4 : 1

2. What volume of 75% alcohol by weight ($d = 0.80\ g/cm^3$) must be used to prepare 150 cm^3 of 30% alcohol by weight ($d = 0.90\ g/cm^3$)?
(a) 67.5 mL (b) 56.25 mL (c) 44.44 mL (d) None of these

3. Calculate the number of millilitres of NH_3 (*aq*) solution ($d = 0.986\ g/mL$) contain 2.5% by weight NH_3, which will be required to precipitate iron as $Fe(OH)_3$ in a 0.8 g sample that contains 50% Fe_2O_3.
(a) 0.344 mL (b) 3.44 mL (c) 17.24 mL (d) 10.34 mL

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

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

How much 80% pure iron could be produced from 120 kg of 90% pure Fe_2O_3 ?
(a) 94.5 kg (b) 60.48 kg (c) 116.66 kg (d) 120 kg

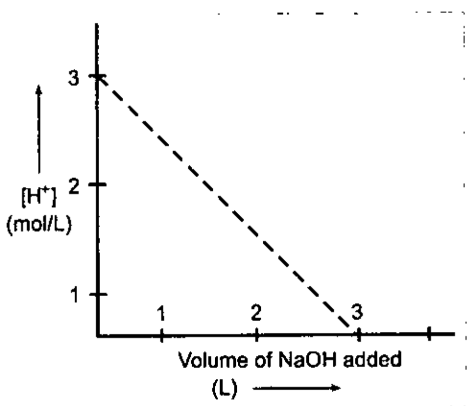
5. A mineral consists of an equimolar mixture of the carbonates of two bivalent metals. One metal is present to the extent of 12.5% by weight. 2.8 g of the mineral on heating lost 1.32 g of CO_2. What is the % by weight of the other metal ?
(a) 87.5 (b) 35.71 (c) 65.11 (d) 23.21

6. 6.2 g of a sample containing Na_2CO_3, $NaHCO_3$ and non-volatile inert impurity on gentle heating loses 5% of its weight due to reaction $2NaHCO_3 \longrightarrow Na_2CO_3 + H_2O + CO_2$. Residue is dissolved in water and formed 100 mL solution and its 10 mL portion requires 7.5 mL of 0.2 *M* aqueous solution of $BaCl_2$ for complete precipitation of carbonates.

Determine weight (in gram) of Na_2CO_3 in the original sample.
(a) 1.59 (b) 1.06 (c) 0.53 (d) None of these

7. Nitric acid can be produced NH_3 in three steps process
(I) $4NH_3(g) + 5O_2(g) \longrightarrow 4NO(g) + 6H_2O(g)$
(II) $2NO(g) + O_2(g) \longrightarrow 2NO_2(g)$
(III) $3NO_2(g) + H_2O(l) \longrightarrow 2HNO_3(aq) + NO(g)$
percent yield of Ist, IInd and IIIrd are respectively 50%, 60% and 80% respectively then what volume of $NH_3(g)$ at 1 atm and 0°C required to produced 1575 g of HNO_3.
(a) 156.25 (b) 350 L (c) 3500 L (d) None of these

8. 1 *M* NaOH solution was slowly added into 1000 mL of 183.75 g impure H_2SO_4 solution and the following plot was obtained. The percentage purity of H_2SO_4 sample and slope of the curve respectively are:



(a) 75%, $-\frac{1}{3}$ (b) 80%, $-\frac{1}{2}$ (c) 80%, -1 (d) None of these

9. MnO_2 on ignition converts into Mn_3O_4. A sample of pyrolusite having 75% MnO_2, 20% inert impurities and rest water is ignited in air to constant weight. What is the percentage of Mn in the ignited sample ?

(a) 24.6% (b) 37% (c) 55.24% (d) 74.05%

10. A 1.0 g sample of a pure organic compound containing chlorine is fused with Na_2O_2 to convert chlorine to NaCl. The sample is then dissolved in water, and the chloride precipitated with $AgNO_3$, giving 1.96 g of AgCl. If the molecular weight of organic compound is 147, how many chlorine atoms does each molecule contain ?

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

11. A 0.60 g sample consisting of only CaC_2O_4 and MgC_2O_4 is heated at 500°C, converting the two salts of $CaCO_3$ and $MgCO_3$. The sample then weighs 0.465 g. If the sample had been heated to 900°C, where the products are CaO and MgO, what would the mixtures of oxides have weighed ?

(a) 0.12 g (b) 0.21 g (c) 0.252 g (d) 0.3 g

12. A metal M forms the sulphate $M_2(SO_4)_3$. A 0.596 gram sample of the sulphate reacts with excess $BaCl_2$ to give 1.220 g $BaSO_4$. What is the atomic weight of M ?

(Atomic weights : S = 32, Ba = 137.3)

(a) 26.9 (b) 69.7 (c) 55.8 (d) 23

13. Urea (H_2NCONH_2) is manufactured by passing $CO_2(g)$ through ammonia solution followed by crystallization. CO_2 for the above reaction is prepared by combustion of hydrocarbon. If combustion of 236 kg of a saturated hydrocarbon (C_nH_{2n+2}) produces as much CO_2 as required for production of 999.6 kg urea then molecular formula of hydrocarbon is:

(a) $C_{10}H_{22}$ (b) $C_{12}H_{26}$ (c) $C_{13}H_{28}$ (d) C_8H_{18}

14. 11.6 g of an organic compound having formula C_nH_{2n+2} is burnt in excess of $O_2(g)$ initially taken in a 22.41 litre steel vessel. Before reaction the gaseous mixture was at 273 K with pressure reading 2 atm. After complete combustion and loss of considerable amount of heat, the mixture of product and excess of O_2 had a temperature of 546 K and 4.6 atm pressure. The formula of organic compound is:

(a) C_2H_6 (b) C_3H_8 (c) C_5H_{12} (d) C_4H_{10}

15. $H_2O_2 + 2KI \xrightarrow{40\% \text{ yield}} I_2 + 2KOH$

$H_2O_2 + 2KMnO_4 + 3H_2SO_4 \xrightarrow{50\% \text{ yield}} K_2SO_4 + 2MnSO_4 + 3O_2 + 4H_2O$

150 mL of H_2O_2 sample was divided into two parts. First part was treated with KI and formed KOH required 200 mL of $M/2$ H_2SO_4 for neutralisation. Other part was treated with $KMnO_4$ yielding 6.74 litre of O_2 at 1 atm. and 273 K. Using % yield indicated find volume strength of H_2O_2 sample used.

(a) 5.04 (b) 10.08 (c) 3.36 (d) 33.6

16. SO_2Cl_2 (sulphuryl chloride) reacts with water to given a mixture of H_2SO_4 and HCl. What volume of 0.2 M $Ba(OH)_2$ is needed to completely neutralize 25 mL of 0.2 M SO_2Cl_2 solution:

(a) 25 mL (b) 50 mL (c) 100 mL (d) 200 mL

17. 5 g sample contain only Na_2CO_3 and Na_2SO_4. This sample is dissolved and the volume made up to 250 mL, 25 mL of this solution neutralizes 20 mL of 0.1 M H_2SO_4.

Calculate the % of Na_2SO_4 in the sample:

(a) 42.4 (b) 57.6 (c) 36.2 (d) none of these

18. 20 mL of 0.2M NaOH(aq) solution is mixed with 35 mL of 0.1M NaOH(aq) solution and the resultant solution is diluted to 100 mL. 40 mL of this diluted solution reacted with 10% impure sample of oxalic acid ($H_2C_2O_4$). The weight of impure sample is:

(a) 0.15 gram (b) 0.135 gram (c) 0.59 gram (d) None of these

19. A silver coin weighing 11.34 g was dissolved in nitric acid. When sodium chloride was added to the solution all the silver (present as $AgNO_3$) was precipitated as silver chloride. The weight of the precipitated silver chloride was 14.35 g. Calculate the percentage of silver in the coin.

(a) 4.8% (b) 95.2% (c) 90% (d) 80%

20. Two elements X (at mass 16) and Y (at mass 14) combine to form compounds A, B and C. The ratio of different masses of Y which combine with a fixed mass of X in A, B and C is 1 : 3 : 5. If 32 parts by mass of X combines with 84 parts by mass of Y in B, then in C, 16 parts by mass of X will combine with :

(a) 14 parts by mass of Y (b) 42 parts by mass of Y

(c) 70 parts by mass of Y (d) 84 parts by mass of Y

21. The conversion of oxygen to ozone occurs to the extent of 15% only. The mass of ozone that can be prepared from 67.2 L of oxygen at 1 atm and 273 K will be :

(a) 14.4 gm (b) 96 gm (c) 640 gm (d) 64 gm

22. RH_2 (ion exchange resin) can replace Ca^{2+} ions in hard water as $RH_2 + Ca^{2+} \longrightarrow RCa + 2H^+$. If 1 L of hard water after passing through RH_2 has pH = 3 then hardness in parts per million of Ca^{2+} is:

(a) 20 (b) 10 (c) 40 (d) 100

23. 100 cm^3 of a solution of an acid (Molar mass = 98) containing 29.4 g of the acid per litre were completely neutralized by 90.0 cm^3 of aq. NaOH containing 20 g of NaOH per 500 cm^3. The basicity of the acid is:

(a) 3 (b) 2 (c) 1 (d) data insufficient

24. 20 mL of 0.1 M solution of compound $Na_2CO_3 \cdot NaHCO_3 \cdot 2H_2O$ is titrated against 0.05 M HCl, x mL of HCl is used when phenolphthalein is used as an indicator and y mL of HCl is used when methyl orange is the indicator in two separate titrations. Hence $(y - x)$ is:

(a) 40 mL (b) 80 mL
(c) 120 mL (d) None of these

25. A sample containing $HAsO_2$ (mol. wt. = 108) and weighing 3.78 g is dissolved and diluted to 250 mL in a volumetric flask. A 50 mL sample (aliquot) is withdrawn with a pipet and titrated with 35 mL of 0.05 M solution of I_2. Calculate the percentage $HAsO_2$ in the sample:

(a) 25% (b) 20%
(c) 10% (d) none of these

26. A mixture of FeO and Fe_2O_3 is completely reacted with 100 mL of 0.25 M acidified $KMnO_4$ solution. The resultant solution was then titrated with Zn dust which converted Fe^{3+} of the solution to Fe^{2+}. The Fe^{2+} required 1000 mL of 0.10 M $K_2Cr_2O_7$ solution. Find out the weight % Fe_2O_3 in the mixture.

(a) 80.85 (b) 19.15
(c) 50 (d) 89.41

27. To a 10 mL, 1 M aqueous solution of Br_2, excess of NaOH is added so that all Br_2 is disproportional to Br^- and BrO_3^-. The resulting solution is free from Br^-, by extraction and excess of OH^- neutralised by acidifying the solution. The resulting solution is sufficient to react with 2 g of impure CaC_2O_4 (M = 128 g/mol) sample. The % purity of oxalate sample is:

(a) 85.3% (b) 12.5%
(c) 90% (d) 64%

28. 0.10 g of a sample containing $CuCO_3$ and some inert impurity was dissolved in dilute sulphuric acid and volume made up to 50 mL. This solution was added into 50 mL of 0.04 M KI solution where copper precipitates as CuI and I^- is oxidized into I_3^-. A 10 mL portion of this solution is taken for analysis, filtered and made up free I_3^- and then treated with excess of acidic permanganate solution. Liberated iodine required 20 mL of 2.5 mM sodium thiosulphate solution to reach the end point.

Determine weight percentage of $CuCO_3$ in the original sample.

(a) 7.41 (b) 74.1
(c) 61.75 (d) None of these

29. 1 mole of equimolar mixture of ferric oxalate and ferrous oxalate will require x mole of $KMnO_4$ in acidic medium for complete oxidation, x is:

(a) 0.5 mole (b) 0.9 mole
(c) 1.2 mole (d) 4.5 mole

30. An impure sample of sodium oxalate ($Na_2C_2O_4$) weighing 0.20 g is dissolved in aqueous solution of H_2SO_4 and solution is titrated at 70°C, requiring 45 mL of 0.02 M $KMnO_4$ solution. The end point is overrun, and back titration in carried out with 10 mL of 0.1 M oxalic acid solution. Find the % purity of $Na_2C_2O_4$ in sample:

(a) 75 (b) 83.75
(c) 90.25 (d) None of these

31. 0.5 g mixture of $K_2Cr_2O_7$ and $KMnO_4$ was treated with excess of KI in acidic medium. Iodine liberated required 150 cm^3 of 0.10 N solution of thiosulphate solution for titration.

Find the percentage of $K_2Cr_2O_7$ in the mixture:

(a) 14.64 (b) 34.2
(c) 65.69 (d) 50

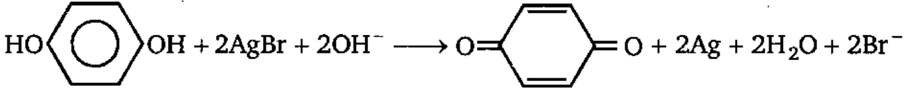
32. A 150 mL of solution of I_2 is divided into two unequal parts. I part reacts with hypo solution in acidic medium. 15 mL of 0.4 M hypo was consumed. II part was added with 100 mL of 0.3 M NaOH solution. Residual base required 10 mL of 0.3 M H_2SO_4 solution for complete neutralization. What was the initial concentration of I_2 ?

(a) 0.08 M (b) 0.1 M
(c) 0.2 M (d) None of these

33. A mixture of H_2SO_4 and $H_2C_2O_4$ (oxalic acid) and some inert impurity weighing 3.185 g was dissolved in water and the solution made up to 1 litre, 10 mL of this solution required 3 mL of 0.1 N NaOH for complete neutralization. In another experiment 100 mL of the same solution in hot condition required 4 mL of 0.02 M $KMnO_4$ solution for complete reaction. The wt. % of H_2SO_4 in the mixture was:

(a) 40 (b) 50
(c) 60 (d) 80

34. During developing of an exposed camera film, one step involves in the following reaction :



(Quinol)

Which of the following best describes the role of quinol ?

(a) It acts as an acid (b) It acts as reducing agent
(c) It acts as oxidant (d) It acts as a base

35. The concentration of oxalic acid is 'x' mol $litre^{-1}$. 40 mL of this solution reacts with 16 mL of 0.05 M acidified $KMnO_4$. What is the pH of 'x' M oxalic acid solution ? (Assume that oxalic acid dissociates completely.)

(a) 1.3 (b) 1.699
(c) 1 (d) 2

Level 3

PASSAGE 1

Oleum is considered as a solution of SO_3 in H_2SO_4, which is obtained by passing SO_3 in solution of H_2SO_4. When 100 g sample of oleum is diluted with desired weight of H_2O then the total mass of H_2SO_4 obtained after dilution is known as % labelling in oleum.

For example, a oleum bottle labelled as '109% H_2SO_4' means the 109 g total mass of pure H_2SO_4 will be formed when 100 g of oleum is diluted by 9 g of H_2O which combines with all the free SO_3 present in oleum to form H_2SO_4 as $SO_3 + H_2O \longrightarrow H_2SO_4$.

1. What is the % of free SO_3 in an oleum that is labelled as '104.5% H_2SO_4' ?
(a) 10 (b) 20 (c) 40 (d) None of these

2. 9.0 g water is added into oleum sample labelled as "112%" H_2SO_4 then the amount of free SO_3 remaining in the solution is : (STP = 1 atm and 273 K)
(a) 14.93 L at STP (b) 7.46 L at STP (c) 3.73 L at STP (d) 11.2 L at STP

3. If excess water is added into a bottle sample labelled as "112% H_2SO_4" and is reacted with 5.3 g Na_2CO_3, then find the volume of CO_2 evolved at 1 atm pressure and 300 K temperature after the completion of the reaction :
(a) 2.46 L (b) 24.6 L (c) 1.23 L (d) 12.3 L

4. 1 g of oleum sample is diluted with water. The solution required 54 mL of 0.4 *N* NaOH for complete neutralization. The % of free SO_3 in the sample is :
(a) 74 (b) 26 (c) 20 (d) None of these

PASSAGE 2

The strength of H_2O_2 is expressed in several ways like molarity, normality, % (*w/V*), volume strength, etc. The strength of "10 V" means 1 volume of H_2O_2 on decomposition gives 10 volumes of oxygen at 1 atm and 273 K or 1 litre of H_2O_2 gives 10 litre of O_2 at 1 atm and 273 K The decomposition of H_2O_2 is shown as under :

$$H_2O_2(aq) \longrightarrow H_2O(l) + \frac{1}{2}O_2(g)$$

H_2O_2 can acts as oxidising as well as reducing agent, as oxidizing agent H_2O_2 converted into H_2O and as reducing agent H_2O_2 converted into O_2, both cases it's *n*-factor is 2.

$\therefore$ Normality of H_2O_2 solution $= 2 \times$ Molarity of H_2O_2 solution

1. What is the molarity of "11.2 *V*" of H_2O_2?
(a) 1 *M* (b) 2 *M* (c) 5.6 *M* (d) 11.2 *M*

2. What is the percentage strength (% *w/V*) of "11.2 *V*" H_2O_2?
(a) 1.7 (b) 3.4 (c) 34 (d) None of these

3. 20 mL of H_2O_2 solution is reacted with 80 mL of 0.05 *M* $KMnO_4$ in acidic medium then what is the volume strength of H_2O_2?
(a) 2.8 (b) 5.6 (c) 11.2 (d) None of these

4. 40 g $Ba(MnO_4)_2$ (mol. wt. = 375) sample containing some inert impurities in acidic medium is completely reacted with 125 mL of "33.6 *V*" of H_2O_2. What is the percentage purity of the sample?
(a) 28.12% (b) 70.31% (c) 85% (d) None of these

PASSAGE 3

A water is said to be a soft water if it produces sufficient foam with the soap and water that does not produce foam with soap is known as hard water. Hardness has been classified into two types (i) Temporary hardness (ii) Permanent hardness.

Temporary hardness is due to presence of calcium and magnesium bicarbonate. It is simply removed by boiling as

$$Ca(HCO_3)_2 \xrightarrow{\Delta} CaCO_3\downarrow + CO_2\uparrow + H_2O$$

$$Mg(HCO_3)_2 \xrightarrow{\Delta} MgCO_3\downarrow + CO_2\uparrow + H_2O$$

Temporary hardness can also be removed by addition of slaked lime, $Ca(OH)_2$

$$Ca(HCO_3)_2 + Ca(OH)_2 \longrightarrow 2CaCO_3\downarrow + 2H_2O$$

Permanent hardness is due to presence of sulphate and chlorides of Ca, Mg, etc. It is removed by washing soda as

$$CaCl_2 + Na_2CO_3 \longrightarrow CaCO_3\downarrow + 2NaCl$$

$$CaSO_4 + Na_2CO_3 \longrightarrow CaCO_3\downarrow + Na_2SO_4$$

Permanent hardness also removed by ion exchange resin process as

$$2RH + Ca^{2+} \longrightarrow R_2Ca + 2H^+$$

$$2ROH + SO_4^{2-} \longrightarrow R_2SO_4 + 2OH^-$$

The degree of hardness of water is measured in terms of ppm of $CaCO_3$. 100 ppm means 100 g of $CaCO_3$ is present in 10^6 g of H_2O. If any water contain 120 ppm of $MgSO_4$, its hardness in terms of $CaCO_3$ = 100 ppm.

1. One litre of a sample of hard water ($d = 1$ g/mL) contains 136 mg of $CaSO_4$ and 190 mg of $MgCl_2$. What is the total hardness of water in terms of $CaCO_3$?
(a) 100 ppm (b) 200 ppm (c) 300 ppm (d) None of these

2. What is the weight of $Ca(OH)_2$ required for 10 litre of water remove temporary hardness of 100 ppm due to $Ca(HCO_3)_2$?
(a) 1.62 g (b) 0.74 g (c) 7.4 g (d) None of these

3. A 200 g sample of hard water is passed through the column of cation exchange resin, in which H^+ is exchanged by Ca^{2+}. The outlet water of column required 50 mL of 0.1 *M* NaOH for complete neutralization. What is the hardness of Ca^{2+} ion in ppm?
(a) 250 ppm (b) 500 ppm (c) 750 ppm (d) 1000 ppm

PASSAGE 4

$$\text{Equivalent weight} = \frac{\text{Molecular weight / Atomic weight}}{n\text{-factor}}$$

n-factor is very important in redox as well as non-redox reactions. With the help of n-factor we can predicts the molar ratio of the reactant species taking part in reactions. The reciprocal of n-factor's ratio of the reactants is the molar ratio of the reactants.

In general n-factor of acid/base is number of moles of H^+/OH^- furnished per mole of acid/base. n-factor of a reactant is no. of moles of electrons lost or gained per mole of reactant.

Example 1 :

1. In acidic medium : $KMnO_4\ (n = 5) \longrightarrow Mn^{2+}$
2. In neutral medium : $KMnO_4\ (n = 3) \longrightarrow Mn^{2+}$
3. In basic medium : $KMnO_4\ (n = 1) \longrightarrow Mn^{6+}$

Example 2 : $FeC_2O_4 \longrightarrow Fe^{3+} + 2CO_2$

Total no. of moles of e^- lost by 1 mole of FeC_2O_4

$$= 1 + 1 \times 2 \Rightarrow 3$$

1. n-factor of $Ba(MnO_4)_2$ in acidic medium is :

(a) 2 (b) 6 (c) 10 (d) None of these

2. For the reaction,

$$H_3PO_2 + NaOH \longrightarrow NaH_2PO_2 + H_2O$$

What is the equivalent weight of H_3PO_2? (mol. wt. is M)

(a) M (b) $M/2$ (c) $M/3$ (d) None of these

3. For the reaction, $Fe_{0.95}O$ (molar mass : M) $\longrightarrow Fe_2O_3$. What is the eq. wt. of $Fe_{0.95}O$?

(a) $\frac{M}{0.85}$ (b) $\frac{M}{0.95}$ (c) $\frac{M}{0.8075}$ (d) None of these

4. In the reaction, $xVO + yFe_2O_3 \longrightarrow FeO + V_2O_5$. What is the value of x and y respectively?

(a) 1, 1 (b) 2, 3 (c) 3, 2 (d) None of these

PASSAGE 5

Consider the following series of reactions :

$$Cl_2 + 2NaOH \longrightarrow NaCl + NaClO + H_2O$$
$$3NaClO \longrightarrow 2NaCl + NaClO_3$$
$$4NaClO_3 \longrightarrow 3NaClO_4 + NaCl$$

1. How much Cl_2 is required to prepare 122.5 g of $NaClO_4$ by above sequencial reactions ?

(a) 284 g (b) 213 g (c) 142 g (d) 71 g

2. How many mole of total NaCl formed by using 1 mole Cl_2 & other reagents in excess ?
(a) $\frac{1}{12}$ mole (b) 1.67 mole (c) 1.75 mole (d) 0.75 mole

3. How many mole of $NaClO_3$ obtained after the complection of reaction by taking 1 mole Cl_2 & other reagents in excess ?
(a) $\frac{1}{3}$ mole (b) Zero (c) $\frac{1}{4}$ mole (d) 1 mole

ONE OR MORE ANSWERS IS/ARE CORRECT

1. 1 g atom of nitrogen represents :
(a) 6.02×10^{23} N_2 molecules (b) 22.4 litre of N_2 at 1 atm and 273 K
(c) 11.2 litre of N_2 at 1 atm and 273 K (d) 14 g of nitrogen

2. 1 g molecule of V_2O_5 contains :
(a) 5 mole of oxygen atom (b) 2 mole of V atom
(c) 1 mole of oxygen atom (d) 2.5 mole of oxygen atom

3. Select dimensionless quantity(ies) :
(a) vapour density (b) molality (c) specific gravity (d) mass fraction

4. Which of the following concentration terms is affected by a change in temperature?
(a) Molarity (b) Molality (c) Normality (d) Specific gravity

5. Which of the following statements regarding the compound A_xB_y is/are correct?
(a) 1 mole of A_xB_y contains 1 mole of A and 1 mole B
(b) 1 equivalent of A_xB_y contains 1 equivalent of A and 1 equivalent of B
(c) 1 mole of A_xB_y contains x moles of A and y moles of B
(d) equivalent weight of A_xB_y = equivalent weight of A + equivalent weight of B

6. 1 mole of $Ba(OH)_2$ will exactly neutralize :
(a) 0.5 mole HCl (b) 1 mole of H_2SO_4 (c) 1 mole of H_3PO_3 (d) 2 mole of H_3PO_2

7. The pair of species having different percentage (mass)of carbon is :
(a) CH_3COOH and $C_6H_{12}O_6$ (b) CH_3COOH and C_2H_5OH
(c) $HCOOCH_3$ and HCOOH (d) C_2H_5OH and CH_3OCH_3

8. 30 mL of CH_3OH ($d = 0.8\ g/cm^3$) is mixed with 60 mL of C_2H_5OH ($d = 0.92\ g/cm^3$) at 25°C to form a solution of density 0.88 g/cm^3. Select the correct option :
(a) Molarity and molality of resulting solution are 6.33 and 13.59 respectively
(b) The mole fraction of solute and molality are 0.385 and 13.59 respectively
(c) Molarity and % change in volume are 13.59 and zero respectively
(d) Mole fraction of solvent and molality are 0.615 and 13.59 respectively

9. Which of the following is/are correct for 17 g/L of H_2O_2 solution?
(a) Volume strengths is 5.6 at 273 K and 1 atm
(b) Molarity of solution is 0.5 M
(c) 1 mL of this solution gives 2.8 mL O_2 at 273 K and 2 atm
(d) The normality of solution is 2 M

10. Solutions containing 23 g HCOOH is/are :

(a) 46 g of 70% $\left(\frac{w}{V}\right)$ HCOOH ($d_{\text{solution}} = 1.40$ g/mL)

(b) 50 g of 10 M HCOOH ($d_{\text{solution}} = 1$ g/mL)

(c) 50 g of 25% $\left(\frac{w}{w}\right)$ HCOOH

(d) 46 g of 5 M HCOOH ($d_{\text{solution}} = 1$ g/mL)

11. A sample of H_2O_2 solution labelled as "28 volume" has density of 265 g/L. Mark the correct option(s) representing concentration of same solution in other units :

(a) $M_{H_2O_2} = 2.5$ (b) $\% \frac{w}{V} = 17$

(c) Mole fraction of $H_2O_2 = 0.2$ (d) $m_{H_2O_2} = 13.88$

12. A mixture of 100 mL of CO, CO_2 and O_2 was sparked. When the resulting gaseous mixture was passed through KOH solution, contraction in volume was found to be 80 mL, the composition of initial mixture may be (in the same order) :

(a) 30 mL, 60 mL, 10 mL (b) 30 mL, 50 mL, 20 mL

(c) 50 mL, 30 mL, 20 mL (d) 20 mL, 70 mL, 10 mL

13. If 1 mole of H_3PO_4 is reacted with 1 mole of $X(OH)_2$ as:

$$H_3PO_4 + X(OH)_2 \longrightarrow XHPO_4 + 2H_2O \text{ then :}$$

(a) The equivalent weight of base is $\frac{\text{mol. wt.}}{2}$

(b) The eq. wt. of H_3PO_4 is $\frac{98}{3}$

(c) The resulting solution is required 1 mole NaOH for complete neutralization

(d) Minimum 1 mole of $X(OH)_2$ is required for complete neutralization of $XHPO_4$

14. Dichromate ion in acidic medium oxidizes stannous ion as:

$$x\text{Sn}^{2+} + y\text{Cr}_2\text{O}_7^{2-} + z\text{H}^+ \longrightarrow a\text{Sn}^{4+} + b\text{Cr}^{3+} + c\text{H}_2\text{O}$$

(a) the value of $x : y$ is 1 : 3 (b) the value of $x + y + z$ is 18

(c) $a : b$ is 3 : 2 (d) the value of $z - c$ is 7

15. When a equimolar mixture of Cu_2S and CuS is titrated with $Ba(MnO_4)_2$ in acidic medium, the final product's contains Cu^{2+}, SO_2 and Mn^{2+}. If the mol. wt. of Cu_2S, CuS and $Ba(MnO_4)_2$ are M_1, M_2 and M_3 respectively then :

(a) eq. wt. of Cu_2S is $\frac{M_1}{8}$

(b) eq. wt. of CuS is $\frac{M_2}{6}$

(c) eq. wt. of $Ba(MnO_4)_2$ is $\frac{M_3}{5}$

(d) Cu_2S and CuS both have same equivalents in mixture

16. Which is/are **INCORRECT** statement ?

(a) Equivalent weight of $H_2PO_3^-$ is 40.5.

(b) Eq. wt. of $H_2PO_4^-$ may be equal to molar mass or less than molar mass depend on reaction.

(c) $KMnO_4$ has maximum eq. wt. in acidic medium.

(d) Oxidation state of H in MgH_2 is greater than in H_2O_2.

MATCH THE COLUMN

Column-I and **Column-II** contains four entries each. Entries of Column-I are to be matched with some entries of Column-II. One or more than one entries of Column-I may have the matching with the same entries of Column-II.

1.

Column-I	**Column-II**
(A) 0.5 mole of $SO_2(g)$	(P) Occupy 11.2 L at 1 atm and 273 K
(B) 1 g of $H_2(g)$	(Q) Weighs 24 g
(C) 0.5 mole of $O_3(g)$	(R) Total no. of atoms = $1.5 \times N_A$
(D) 1 g molecule of $O_2(g)$	(S) Weighs 32 g

2.

Column-I	**Column-II**
(A) 44 g CO_2 gas	(P) 1g molecule
(B) 35.2 g of CH_4	(Q) N_A molecule
(C) 48 g of O_3 gas	(R) $22N_A$ electrons
(D) 44 g of N_2O gas	(S) 49.28 L at 1 atm and 273 K
	(T) N_A atoms of oxygen

3.

Column-I **[Atomic masses (*M*)]**				**Column-II** **(% composition of heavier isotope)**
	Isotope-II	Isotope-II	Average	
(A)	$(z-1)$	$(z+3)$	z	(P) 25% by moles
(B)	$(z+1)$	$(z+3)$	$(z+2)$	(Q) 50% by moles
(C)	z	$3z$	$2z$	(R) % by mass dependent on z
(D)	$(z-1)$	$(z+1)$	z	(S) 75% by mass

4.

Column-I	Column-II
(A) When Bi_2S_3 converted into Bi^{5+} and S	(P) 18
(B) When $Al_2(Cr_2O_7)_3$ reduced into Cr^{3+} in acidic medium	(Q) 11
(C) When FeS_2 converted into Fe_2O_3 and SO_2	(R) 2
(D) When $Mn(NO_3)_2$ converted into MnO_4^{2-} and NO	(S) 10

5.

Column-I	Column-II
(A) Eq. wt. $= \dfrac{\text{Molecular weight}}{33}$	(P) When CrI_3 oxidises into $Cr_2O_7^{2-}$ and IO_4^-
(B) Eq. wt. $= \dfrac{\text{Molecular weight}}{27}$	(Q) When $Fe(SCN)_2$ oxidises into Fe^{3+}, SO_4^{2-}, CO_3^{2-} and NO_3^-
(C) Eq. wt. $= \dfrac{\text{Molecular weight}}{28}$	(R) When NH_4SCN oxidizes into SO_4^{2-}, CO_3^{2-} and NO_3^-
(D) Eq. wt. $= \dfrac{\text{Molecular weight}}{24}$	(S) When As_2S_3 oxidises into AsO_3^- and SO_4^{2-}

6.

Column-I	Column-II
(A) $\underline{P_2H_4} \longrightarrow PH_3 + P_4H_2$	(P) $E = \dfrac{3M}{4}$
(B) $\underline{I_2} \longrightarrow I^- + IO_3^-$	(Q) $E = \dfrac{3M}{5}$
(C) $MnO_4^- + Mn^{2+} + H_2O \longrightarrow \underline{Mn_3O_4} + H^+$	(R) $E = \dfrac{15M}{26}$
(D) $\underline{H_3PO_2} \longrightarrow PH_3 + H_3PO_3$	(S) $E = \dfrac{5M}{6}$

7. A sample of raw material contain $NaNO_3$ also contains $NaIO_3$. The $NaIO_3$ can be used as a source of iodine, produced in the following reactions:

$$IO_3^- + HSO_3^- \longrightarrow I^- + SO_4^{2-} \quad \ldots(1)$$

$$I^- + IO_3^- \longrightarrow I_2 + H_2O \quad \ldots(2)$$

One litre of sample solution containing 396 g of $NaIO_3$ is treated with stoichiometric quantity of $NaHSO_3$. Now a substantial amount of same solution is added to reaction mixture to bring about the reaction (2).

Column-I	Column-II
(A) n-factor of IO_3^- in reaction (2)	(P) 6
(B) Number of moles of HSO_3^- used in reaction (1)	(Q) 1.2
(C) Moles of I_2 produced	(R) 2
(D) Equivalents of IO_3^- used in reaction (2)	(S) 5

8.

Column-I	Column-II (Type of Redox Reaction)
(A) $Br_2 + OH^- \longrightarrow BrO_3^- + Br^-$	(P) Intermolecular
(B) $FeCl_2 + KMnO_4 + HCl \longrightarrow MnCl_2 + FeCl_2$	(Q) Interamolecular
(C) $Ag_2O \longrightarrow Ag + \frac{1}{2}O_2$	(R) Disproportion
(D) $NH_4NO_3 \longrightarrow NO_2 + H_2O$	(S) Comproportion

ASSERTION-REASON TYPE QUESTIONS

Each question contains STATEMENT-1 (Assertion) and STATEMENT-2 (Reason).

Examine the statements carefully and mark the correct answer according to the instructions given below

(A) If both the statement are TRUE and STATEMENT-2 is the correct explanation of STATEMENT-1

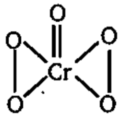
(B) If both the statement are TRUE but STATEMENT-2 is NOT the correct explanation of STATEMENT-1

(C) If STATEMENT-1 is TRUE and STATEMENT-2 is FALSE

(D) If STATEMENT-1 is FALSE and STATEMENT-2 is TRUE

1. **STATEMENT-1 :** Specific gravity is dimensionless.
   STATEMENT-2 : Specific gravity is density of a substance measured w.r.t. density of water at 4°C.
2. **STATEMENT-1 :** Molarity of pure water is 55.55 M at 298 K.
   STATEMENT-2 : Molarity is temperature dependent.
3. **STATEMENT-1 :** Gram molecular weight of O_2 is 32.
   STATEMENT-2 : Relative atomic weight of oxygen is 32 a.m.u.
4. **STATEMENT-1 :** The oxidation state of S in $H_2S_2O_8$ is 6.
   STATEMENT-2 : Max. oxidation state of S is 6 because the max. oxidation state of an element is it's no. of valence electron.
5. **STATEMENT-1 :** 0.1 M $H_3PO_3(aq)$ solution has normality equal to 0.3 N when completely reacted with NaOH.
   STATEMENT-2 : H_3PO_3 is a dibasic acid.

6. **STATEMENT-1 :** MnO_2 can act as an oxidizing agent as well as reducing agent.
   STATEMENT-2 : Oxidation state of Mn lies between highest and lowest oxidation state.
7. **STATEMENT-1 :** Equivalent volume of H_2 is 11.2 L at 1 atm and 273 K.
   STATEMENT-2 : 1/2 mole H_2 has produced when 1 mole of $H^+(aq)$ accepted 1 mole of e^-.
8. **STATEMENT-1 :** For the reaction, $Na_2CO_3 + HCl \longrightarrow NaCl + NaHCO_3$, the suitable indicator is phenolphthalein.
   STATEMENT-2 : Phenolphthalein provide it's colour in acidic medium.
9. **STATEMENT-1 :** $[Fe(CN)_6]^{4-} \longrightarrow Fe^{3+} + CO_2 + NO_3^-$, the equivalent weight of reactant is 3.74.
   STATEMENT-2 : Equivalent weight of reactant $= \dfrac{\text{Mol. wt.}}{61}$.
10. **STATEMENT-1 :** In the balanced redox reaction,
$$xAs_2S_3 + yNO_3^- + 4H_2O \longrightarrow aAsO_4^{3-} + bNO + cSO_4^{2-} + 8H^+$$
    the n-factor of As_2S_3 and NO_3^- is 28 and 3 respectively.
    STATEMENT-2 : Molar ratio is reciprocal of n-factor's ratio so $x : y$ is 3 : 28.
11. **STATEMENT-1 :** $NaOH + H_3PO_4 \longrightarrow NaH_2PO_4 + H_2O$ in given reaction equivalent weight of H_3PO_4 is $M/3$
    STATEMENT-2 : H_3PO_4 is tribasic acid.
12. **STATEMENT-1 :** In CrO_5 oxidation number of Cr is +6.
    STATEMENT-2 : CrO_5 has butterfly structure in which peroxide bonds are present.



13. **STATEMENT-1 :** $I_2 \rightarrow IO_3^- + I^-$. This reaction is a disproportionation reaction.
    STATEMENT-2 : Oxidation number of I can vary from −1 to +7.
14. **STATEMENT-1 :** Fluorine exists only in −1 oxidation state.
    STATEMENT-2 : Fluorine has $2s^2 2p^5$ configuration.
15. **STATEMENT-1 :** H_2SO_4 can not act as reducing agent.
    STATEMENT-2 : Sulphur can not increase its oxidation number beyond +6.

SUBJECTIVE PROBLEMS

1. What volume of a liquid (in L) will contain 10 mole ? If molar mass of liquid is 280 and its density is 1.4g/mL.
2. 16 g of SO_x gas occupies 5.6L at 1 atm and 273K. What will be the value of x ?
3. 200mL of 1M HCl is mixed with 300mL of 6M HCl and the final solution is diluted to 1000mL. Calculate molar concentration of $[H^+]$ ion.
4. $N_2(g)$ reacts with $H_2(g)$ in either of the following ways depending upon supply of $H_2(g)$:
   $N_2(g) + H_2(g) \longrightarrow N_2H_2(l)$

$N_2(g) + 2H_2(g) \longrightarrow N_2H_4(g)$

If $5\,L\,N_2(g)$ and $3\,L\,H_2(g)$ are taken initially (at same temperature and pressure). Calculate the contraction in volume after the reaction (in L).

5. One commercial system removes SO_2 emission from smoke at 95°C by the following set of reaction :

$$SO_2(g) + Cl_2(g) \longrightarrow SO_2Cl_2(g)$$
$$SO_2Cl_2(g) + H_2O(l) \longrightarrow H_2SO_4 + HCl$$
$$H_2SO_4 + Ca(OH)_2 \longrightarrow CaSO_4 + H_2O$$

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

6. W is the weight of iron (in g) which will be converted into Fe_3O_4 by the action of 18 g of steam on it. What is the value of $W/7$?

$$[Fe + H_2O \longrightarrow Fe_3O_4 + H_2]$$

7. Calculate the total mole of atoms of each element present in 122.5 g of $KClO_3$.

8. On dissolving 2.0 g of metal in sulphuric acid, 4.51 g of the metal sulphate was formed. The specific heat of the metal is 0.057 cal $g^{-1}\,°C^{-1}$. What is the valency of the metal ?

9. One gram of a metallic chloride was found to contain 0.835 g of chlorine. Its vapour density metallic chloride is 85.5. If its molecular formula is M_xCl_y, then what is value of $(x+y)$?

10. 0.7875 g of crystalline barium hydroxide is dissolved in water. For the neutralization of this solution. 20 mL of $N/4$ HNO_3 is required. How many mole of water are present in one mole of this base ? (Given : Atomic mass Ba = 137, O = 16, N = 14, H = 1)

11. 2.0g of polybasic organic acid (Molecular wt. = 600) required 100 mL of a $\frac{M}{6}$ NaOH solution for complete neutralisation. Find the basicity of acid.

12. A mixture contains 1.0 mole each of NaOH, Na_2CO_3 and $NaHCO_3$. When half of mixture is titrated with HCl, it required x mole of HCl in presence of phenolphthalein. In another experiment, half of mixture required y mole of same HCl in presence of methyl orange. Find the value of $(x+y)$.

13. When BrO_3^- ion reacts with Br^- ion in acidic medium, Br_2 is liberated. Calculate the ratio of molecular weight and equivalent weight of $KBrO_3$.

14. A volume of 12.5 mL of 0.05M SeO_2 reacts with 25 mL of 0.1M $CrSO_4$ which is oxidised to Cr^{3+}. To what oxidation state was the selenium converted by the reaction ?

15. A 0.276g impure sample of copper ore is dissolved and Cu^{2+} is titrated with KI solution. I_2 liberated required 40 mL of 0.1M $Na_2S_2O_3$ solution for titration. What is the % of impurities in the ore ?

16. A sample of 28 mL of $H_2O_2\,(aq)$ solution required 10 mL of 0.1M $KMnO_4\,(aq)$ solution for complete reaction in acidic medium. What is the volume strength of H_2O_2 ?

17. In the redox reaction,

$xNO_3^- + y\,As_2S_3 + zH_2O \longrightarrow \text{---}\,AsO_4^{3-} + \text{---}\,NO + \text{---}\,SO_4^{2-} + \text{---}\,H^+.$

What is the value of $\frac{x}{z}$?

18. On heating 0.220 g of a metallic oxide in presence of hydrogen, 0.045 g of water is formed. If the equivalent weight of the metal is E, then what is the value of $E/9$?

19. 10 g mixture of $K_2Cr_2O_7$ and $KMnO_4$ was treated with excess of KI in acidic medium. Iodine liberated required 100 cm^3 of 2.2 *N* sodium thiosulphate solution for titration. If the mass percent of $KMnO_4$ in the mixture Z, then what is the value of $2Z/5$?

20. In an ore the only oxidisable material is Sn^{2+}. This ore is titrated with a dichromate solution containing 2.5 g $K_2Cr_2O_7$ in 0.50 litre. A 0.40 g of sample of the ore required 10.0 cm^3 of the titrant to reach equivalent point. If the percentage of tin in ore is x, then what is the value of $x/17$? (K = 39.1, Cr = 52, Sn = 118.7)

ANSWERS

Level 1

1. (c)	2. (a)	3. (b)	4. (d)	5. (c)	6. (d)	7. (c)	8. (c)	9. (b)	10. (b)
11. (d)	12. (b)	13. (b)	14. (a)	15. (d)	16. (d)	17. (d)	18. (d)	19. (d)	20. (a)
21. (a)	22. (c)	23. (b)	24. (b)	25. (a)	26. (d)	27. (d)	28. (c)	29. (c)	30. (c)
31. (b)	32. (a)	33. (a)	34. (a)	35. (b)	36. (d)	37. (b)	38. (d)	39. (c)	40. (a)
41. (c)	42. (d)	43. (d)	44. (a)	45. (b)	46. (a)	47. (c)	48. (d)	49. (a)	50. (a)
51. (c)	52. (c)	53. (c)	54. (a)	55. (c)	56. (a)	57. (d)	58. (c)	59. (d)	60. (c)
61. (c)	62. (d)	63. (d)	64. (b)	65. (d)	66. (b)	67. (d)	68. (a)	69. (c)	70. (d)
71. (c)	72. (a)	73. (d)	74. (d)	75. (d)	76. (b)	77. (a)	78. (a)	79. (b)	80. (c)
81. (c)	82. (d)	83. (a)	84. (b)	85. (c)	86. (d)	87. (a)	88. (d)	89. (d)	90. (b)
91. (c)	92. (a)	93. (a)	94. (c)	95. (a)	96. (b)	97. (b)	98. (c)	99. (c)	100. (c)
101. (d)	102. (c)	103. (a)	104. (c)	105. (a)	106. (b)	107. (b)	108. (b)	109. (b)	110. (a)
111. (b)	112. (d)	113. (c)	114. (d)	115. (b)	116. (c)	117. (c)	118. (a)	119. (b)	120. (b)
121. (c)	122. (a)	123. (b)	124. (d)	125. (b)	126. (d)	127. (b)	128. (c)	129. (a)	130. (c)
131. (c)	132. (a)	133. (d)	134. (b)	135. (d)	136. (d)	137. (a)	138. (a)	139. (a)	140. (d)
141. (a)	142. (c)	143. (b)	144. (b)	145. (d)	146. (d)	147. (d)	148. (b)	149. (b)	150. (a)
151. (b)	152. (d)	153. (c)	154. (c)	155. (a)	156. (a)	157. (b)	158. (b)	159. (c)	160. (b)
161. (a)	162. (b)	163. (c)	164. (c)	165. (c)	166. (c)	167. (d)	168. (b)	169. (b)	170. (a)
171. (c)	172. (a)	173. (a)	174. (c)	175. (b)	176. (c)	177. (a)	178. (d)	179. (a)	180. (d)
181. (b)	182. (d)	183. (a)	184. (d)	185. (c)	186. (a)	187. (b)	188. (d)	189. (d)	190. (b)
191. (a)	192. (d)	193. (c)	194. (a)	195. (c)	196. (a)	197. (a)	198. (c)	199. (d)	200. (d)

Level 2

1. (a)	2. (a)	3. (d)	4. (a)	5. (d)	6. (b)	7. (c)	8. (c)	9. (c)	10. (b)
11. (c)	12. (a)	13. (b)	14. (d)	15. (d)	16. (b)	17. (b)	18. (a)	19. (b)	20. (c)
21. (a)	22. (a)	23. (a)	24. (b)	25. (a)	26. (a)	27. (d)	28. (b)	29. (b)	30. (b)
31. (a)	32. (b)	33. (a)	34. (b)	35. (c)					

Level 3

Passage–1	1. (b)	2. (c)	3. (c)	4. (b)
Passage–2	1. (a)	2. (b)	3. (b)	4. (b)
Passage–3	1. (c)	2. (b)	3. (b)	
Passage–4	1. (c)	2. (a)	3. (a)	4. (b)
Passage–5	1. (a)	2. (c)	3. (b)	

One or More Answers is/are correct

1. (c,d)	2. (a,b)	3. (a,c,d)	4. (a,c,d)	5. (b,c,d)	6. (b,c,d)	7. (b,c)	8. (b,d)
9. (a,b,c)	10. (a,b)	11. (a,c,d)	12. (a,b)	13. (a,c)	14. (b,c,d)	15. (a,b)	16. (a,c,d)

Match the Column

1. A→ P, R, S; B→ P; C→ P, Q, R; D→ S
2. A→ P, Q, R; B→ R, S ; C→ P, Q; D→ P, Q, R, T
3. A→ P, R; B→ Q, R; C→ Q, S; D→ Q, R
4. A→ S; B→ P; C→ Q; D→ R
5. A→ Q; B→ P; C→ S; D→ R
6. A→ S; B→ Q; C→ R; D→ P
7. A→ S; B→ P; C→ Q; D→ R
8. A→ P, R; B→ P; C→ Q; D→ Q, S

Assertion-Reason Type Questions

1. (A)	2. (B)	3. (C)	4. (A)	5. (D)	6. (A)	7. (A)	8. (C)	9. (D)	10. (A)
11. (D)	12. (A)	13. (B)	14. (B)	15. (A)					

Subjective Problems

1. 2	2. 2	3. 2	4. 6	5. 8	6. 6	7. 5	8. 3	9. 5	10. 8
11. 5	12. 3	13. 5	14. 0	15. 8	16. 1	17. 7	18. 4	19. 6	20. 3

Hints and Solutions

Level 1

7. (c) No. of moles of $H_2O\ (l) = \frac{54}{18}$

$(d = 1.0\,g/mL \text{ for } H_2O)$

H has no neutron

$\therefore$ no. of neutrons in $H_2O = 3 \times 8 \times N_A$

16. (d) Atomic weight of an element

$x = 6.643 \times 10^{-23} \times N_A = 40$

no. of moles of $x = \frac{20 \times 1000}{40} = 500$

20. (a) (I) 0.5 mole $O_3 = 24\,g\,O_3$;

(II) 0.5 g atom of oxygen = 8 g

(III) $\frac{3.011 \times 10^{23}}{6.022 \times 10^{23}} \times 32 = 16\,g\,O_2$

(IV) $\frac{5.6}{22.4} \times 44\,g\,CO_2 = 11\,g\,CO_2$

22. (c) No. of protons in ${}_6C^{14} = 6$;

No. of neutrons in ${}_6C^{14} = 8$;

As per given new atomic mass of

${}_6C^{14} = 12 + 4 = 16$

(As the mass of e^- is negligible as compared to neutron and proton)

% increase in mass $= \frac{16 - 14}{14} \times 100 = 14.28$

29. (c) $d = \frac{PM}{RT}$

$$1.15 = \frac{\left(\frac{740}{760}\right) \times M}{0.0821 \times 300}$$

$\therefore$ $M = 29.09$. Let mole fraction of N_2 is x.

$29.09 = 28 \times x + 32(1 - x)$;

$x = 0.7275$

$$\text{wt. \%} = \text{mole \%} \times \frac{\text{mol. wt. of } N_2}{\text{average mol. wt. of air}}$$

$$= 72.75 \times \frac{28}{29.09} = 70.02$$

30. (c) No. of moles of CO_2 in 100 g mixture

$$= \frac{66}{44} = 1.5$$

No. of moles of H_2 in 100 g mixture

$$= \frac{34}{2} = 17$$

$$M_{\text{average}} = \frac{100}{18.5} = 5.40$$

$$\text{V. D.} = \frac{5.4}{2} = 2.7$$

31. (b) Let 1 mole of mixture has x mole N_2O_4

$2 \times 27.6 = x\,(92) + (1 - x)\,46$; $x = 0.2$

33. (a) Let mole % of ${}^{26}Mg$ be x

$$\therefore \frac{(21 - x)\,25 + x\,(26) + 79\,(24)}{100} = 24.31$$

$$x = 10\%$$

36. (d) Let mole fraction of O_2 is x

$40 = 32 \times x + 80\,(1 - x)$

or $x = 5/6$

$a : b = x : (1 - x) = \frac{5}{6} : \frac{1}{6}$

When ratio is changed

$$M_{\text{mixture}} = 32 \times \frac{1}{6} + 80 \times \frac{5}{6} = 72$$

47. (c) Metal oxide = 2.74g;

wt. of vanadium = 1.53 g

% of V $= \frac{1.53}{2.74} \times 100 = 55.83$

Thus, % of O = 100 − 55.83 = 44.17

No. of moles of V $= \frac{55.83}{52} = 1.1$

No. of moles of O $= \frac{44.17}{16} = 2.76$

Simplest ratio of V and O = 1:2.5 or 2 :5

Hence, the empirical formula $= V_2O_5$

49. (a) $Na_2CO_3 \cdot xH_2O\,(s) \longrightarrow Na_2CO_3(s) + xH_2O(g)$.

Let 100 g of $Na_2CO_3 \cdot xH_2O$ be present

$\therefore \dfrac{100\,x}{106 + 18x}$ mole of H_2O formed;

$$63 = \frac{100x}{106 + 18x}(18)$$

$$6678 + 1134x = 1800x$$

$$666x = 6678$$

$$x \simeq 10$$

51. (c) % of O $= \dfrac{16 \times 27}{(100 + 3 \times 310)} \times 100 = 41.94\%$

53. (c) $d = \dfrac{PM}{RT} \Rightarrow M = \dfrac{dRT}{P} = \dfrac{2.28 \times 0.0821 \times 300}{1} = 56.15$ g/mol

E. F. $= \dfrac{85.7}{12} : \dfrac{14.3}{1} = 7.14 : 14.3 = 1 : 2; \therefore$ E.F. is CH_2; M.F. $= (CH_2)_n$

where $n = \dfrac{56.15}{12 + 2} \simeq 4$;

$\therefore$ M.F. is C_4H_8

59. (d) 100 g compound contain 43.8 oxygen; 1 g oxygen present with $\dfrac{100}{43.8}$ g adipic acid

16×4 g or 4 mole oxygen present with $\dfrac{100}{43.8} \times 16 \times 4 \simeq 146$ g compound

$\therefore$ mol. wt. of adipic acid is 146.

60. (c) Mol. wt. of $XY_2 = \dfrac{5}{0.05} = 100$

Mol. wt. of $X_2Y_3 = \dfrac{85}{3.011 \times 10^{23}} \times N_A = 170$

Let molar mass of X and Y are a and b respectively

$$\therefore \quad a + 2b = 100$$

$$2a + 3b = 170;$$

$$a = 40;$$

$$b = 30$$

61. (c) $CO_2 = \dfrac{88}{44} = 2$ mole of $CO_2 = 2$ mole of C

$H_2O = \dfrac{36}{18} = 2$ mole of $H_2O = 4$ mole of H

Mass of C + Mass of H + Mass of O = 44

$\Rightarrow 24 + 4 + x = 44; x = 16$

$\therefore$ mole of O = 1 and molecular formula is C_2H_4O.

62. (d) $\dfrac{4.92}{1000} \times 1 = \dfrac{40 \times 10^{-3}}{M} \times 0.0821 \times 300$;

$M \simeq 200$; Atomic mass of $X = 100$.

66. (b) $Ti \quad + \quad O_2 \longrightarrow Ti_{1.44}O$

$\dfrac{1.44}{48}$ mole $\qquad \dfrac{x}{48\,(1.44) + 16}$ mole

$\therefore \quad \frac{1.44}{48} = \frac{1.44x}{48(1.44)+16}$

$x = 1.77$ g

69. (c) $3Fe_2O_3(s) \longrightarrow 2Fe_3O_4 + \frac{1}{2}O_2$

480 g Fe_2O_3 provide 16 g O_2. For loss of

$0.04\text{ g } O_2 \longrightarrow 0.04 \times \frac{480}{16} = 1.2\text{ g } Fe_2O_3$

% by mass of $SiO_2 = \frac{0.8}{2.0} \times 100 = 40\%$

70. (d) Wt. of S_8 in sample = 160 g;

Moles of $S_8 = \frac{160}{32 \times 8} = 0.625$

No. of moles of O_2 required $= 0.625 \times 8$

Vol. of O_2 required at STP $= 22.4 \times 5$

$\therefore$ Vol. of air required at STP $= 22.4 \times 5 \times \frac{100}{21} = 533.33$ L

71. (c)

	$2Fe(NO_3)_3$	$+ 3Na_2CO_3 \longrightarrow Fe_2(CO_3)_3 + 6NaNO_3$
mole	2.5	3.6
mole/ stoichiometric coefficient	1.25	1.2

Limiting reagent is Na_2CO_3 so moles of $NaNO_3$ should be formed $= 3.6 \times 2 = 7.2$

% yield $= \frac{6.3}{7.2} \times 100 = 87.5$

76. (b) Produced mass of $H_3PO_4 = \left(\frac{62}{4 \times 31}\right) \times 0.85 \times 0.9 \times 4 \times 98 = 149.94$ g

79. (b) $CO_2 + 2NaOH \longrightarrow Na_2CO_3 + H_2O$

$n_{NaOH} = 1$; $\therefore$ CO_2 present in mixture $= 0.5$ and Co present $= 0.3$ mole

When more CO_2 produced $= 0.3$, more NaOH required $= 0.3 \times 2 = 0.6$ mole

81. (c) No. of moles of $Ba(OH)_2 = \frac{20 \times 342}{100 \times 171}$

$= 0.4$ mole

or moles of $OH^- = 0.4 \times 2$

No. of moles of $HNO_3 = 1.2 \times 2 = 2.4$ mole

Hence, the final solution is acidic due to presence of excess H^+

$$[H^+] = \frac{(2.4 - 0.8) \times 1000}{1200 + \frac{342}{0.57}} = 0.888\ M$$

82. (d) Total moles of $H_2SO_4 = 0.1$ mole

Total volume $= \frac{150 + 400}{1.25} = \frac{550}{1.25} = 440$

$\therefore \quad M = \frac{0.1}{440} \times 1000 = \frac{1}{4.4} = 0.227\ M$

83. (a) $Zn + 2HCl \longrightarrow ZnCl_2 + H_2$;

moles of H_2 evolved = 2

$\therefore$ moles of HCl required = 4

$\therefore \dfrac{V \times 1.2 \times 0.365}{36.5} = 4; \quad V = 333.33\text{ mL}$

84. (b) $C_2H_6 + 3.5O_2 \longrightarrow 2CO_2 + 3H_2O;$

$C_2H_4 + 3O_2 \longrightarrow 2CO_2 + 2H_2O$

Let vol. of ethane is x,

$22.4 \times 4 = 3.5x + 3(28 - x)$

$\Rightarrow x = 11.2$ litre

at constant T and P, $V \propto n$;

$\therefore$ Mole fraction of C_2H_6 in mixture

$$= \frac{11.2}{28} = 0.4$$

87. (a) $\dfrac{\text{mass of } Al_2(SO_4)_3}{\text{mass of water}} \times 10^6 = 34.2$

1 litre solution contains 1000 g of water

$\Rightarrow$ In 1 litre solution, mass of $Al_2(SO_4)_3$

$$= \frac{34.2 \times 1000}{10^6} = 34.2\text{ mg}$$

molarity of $Al_2(SO_4)_3 = \dfrac{34.2 \times 10^{-3}}{342}\,M$

$= 10^{-4}\,M$

$$\underset{10^{-4}\,M}{Al_2(SO_4)_3(aq)} \longrightarrow \underset{2 \times 10^{-4}\,M}{2Al^{3+}(aq)} + \underset{3 \times 10^{-4}\,M}{3SO_4^{2-}(aq)}$$

$[SO_4^{2-}] = 3 \times 10^{-4}\,M$

90. (b) 1000 mL solution contain 2 mole of ethanol or 1000×1.025 g solution contain 2 mole of ethanol

wt. of solvent $= 1000 \times 1.025 - 2 \times 46$

$$m = \frac{2}{1000 \times 1.025 - 2 \times 46} \times 1000$$

$$m = \frac{2}{933} \times 1000 = 2.143$$

93. (a) The sample of H_2SO_4 is 80% by volume

$\therefore W_{H_2SO_4} = 800$ g in 1000 mL

Volume of solution = 1000 mL

Weight of solution $= 1000.0 \times 1.80$

$= 1800$ g

Weight of water $= 1800 - 800 = 1000$ g

Molality $= \dfrac{800 \times 1000}{98 \times 1000} = 8.16\text{ mol kg}^{-1}$

96. (b) m-moles of HNO_3 required

$= 250 \times 1.2 = 300$

100 g solution contains 63 g HNO_3 or

$\dfrac{100}{1.4}$ mL solution contain 1 mole HNO_3

$\therefore$ molarity of HNO_3 solution

$$= \frac{1000}{100} \times 1.40 = 14$$

$\therefore 14 \times V = 300 \quad$ or $\quad V = 21.42\text{ mL}$

97. (b) 50 mL $BaCl_2$ (aq) solution contain 10.4 g $BaCl_2$

$\therefore \quad n_{BaCl_2} = \dfrac{10.4}{137 + 71} = 0.05$

moles of H_2SO_4 in 100 mL H_2SO_4 (aq) solution $= \dfrac{9.8}{98} = 0.1$

$BaCl_2 + H_2SO_4 \longrightarrow BaSO_4 + 2HCl;$

moles of HCl formed = 0.1

$$[Cl^-] = \frac{0.1 \times 1000}{50 + 100} = 0.666\,M$$

98. (c) No. of moles of HCl are more than NaOH, so final solution becomes acidic.

99. (c) Let vol. is x mL, $\quad x \times 0.1 \times 2 - 50 \times 0.1$

$= (x + 50) \times 0.05 \times 2$

$0.2x - 5 = 0.1x + 5$

$\Rightarrow 0.1x = 10 \Rightarrow x = 100\text{ mL}$

100. (c) $[HCl] = \dfrac{1 \times 4V + 2 \times V}{5V} = 1.2\,M$

102. (c) Molarity $= \dfrac{28}{11.2} = 2.5\,M$

1000 mL of solution contains 2.5 mole H_2O_2

molality, $m = \dfrac{2.5}{1250 - 85} \times 1000 = 2.15\,m$

103. (a) The reaction that takes place is

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

$\because$ 143.5 g of AgCl is produced from 58.5 g NaCl

$\therefore$ 14 g of AgCl will produce from

$$\frac{58.5 \times 14}{143.5} = 5.70\text{ g}$$

This is the amount of NaCl in common salt;

% purity $= \dfrac{5.70}{6} \times 100 = 95\%$

104. (c) Let no. of moles of $Al_2(SO_4)_3$ in solution is x

$$\frac{x}{2684 - x \times 342} \times 1000 = 1$$

$x = 2$

$2Al_2(SO_4)_3 \longrightarrow 6$ moles SO_4^{2-}

$\therefore$ 6 moles of $BaSO_4$

105. (a) 0.478 mL $\equiv$ 0.478 g of water; 10^9 g water contain 0.10 g $CHCl_3$

$\therefore$ 0.478 g water contain

$$\frac{0.1}{10^9} \times 0.478 \text{ g CHCl}_3$$

$$\therefore \; n_{CHCl_3} = \frac{0.1}{10^9} \times \frac{0.478}{119.5}$$

$$\therefore \text{ No. of molecules} = \frac{0.1}{10^9} \times \frac{0.478}{119.5} \times N_A$$

$$= 4 \times 10^{-3} \times N_A$$

107. (b) $B \; H_2PtCl_6 \longrightarrow Pt$; $\dfrac{12}{M_B + 410} = \dfrac{5}{195} =$ moles of Pt; Molecular mass of base = 58

109. (b) Moles of $Ag_3A = \dfrac{\text{moles of Ag}}{3}$

$$= \frac{0.607}{M} = \frac{0.37}{108} \times \frac{1}{3} \Rightarrow M = 531$$

$\therefore$ mol. wt. of H_3A= mol. wt. of $Ag_3A - 3 \times$ At. wt. of Ag + 3 × At. wt. of H = 210

110. (a) Equivalents of KOH used by oil

$= [25 \times 0.40 - 8.5 \times 0.28 \times 2] \times 10^{-3}$

$\Rightarrow$ Moles of KOH used $= 5.24 \times 10^{-3}$

$\Rightarrow$ Mass of KOH used in milligrams

$= 5.24 \times 10^{-3} \times 56 \times 1000$

$= 223.44$

$$\therefore \text{ Saponification number} = \frac{223.44}{2}$$

$$= 146.72$$

113. (c) 100 mL gaseous mixture contain 20 mL C_3H_8

So, volume of CH_4 and CO

$= (100 - 20) = 80$ mL

$$C_3H_8 + 5O_2 \longrightarrow 3CO_2 + 4H_2O$$

$$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O;$$

$$CO + \frac{1}{2}O_2 \longrightarrow CO_2$$

80 mL (CH_4 and CO) will produce 80 mL CO_2; C_3H_8 will produce $= 3 \times 20 = 60$ mL

Total CO_2 produce $= 80 + 60 \Rightarrow 140$

114. (d) Let the volume of CO, CH_4 and Ne be x, y & z respectively

$$\underset{x}{CO} + \underset{x/2}{\frac{1}{2}O_2} \longrightarrow \underset{x}{CO_2};$$

$$\underset{y}{CH_4} + \underset{2y}{2O_2} \longrightarrow \underset{y}{CO_2} + 2H_2O\,(l)$$

Remaining volume of $O_2 = 10 - \dfrac{x}{2} - 2y$

Volume after reaction :

$$x + y + 10 - \frac{x}{2} - 2y + z = 36.5 \qquad \text{...(i)}$$

$$x + y = 9 \qquad \text{...(ii)}$$

$$x + y + z = 40 \qquad \text{...(iii)}$$

by Eq. (i), (ii) and (iii)

Volume of $CH_4 = 6$ mL;

$$\% \text{ of } CH_4 = \frac{6}{40} \times 100 \Rightarrow 15$$

115. (b) Suppose, the volume of propane = V L

$$\therefore \underset{V}{C_3H_8(g)} + \underset{5V}{5O_2(g)} \longrightarrow \underset{3V}{3CO_2(g)} + 4H_2O(l)$$

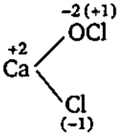
$$\underset{(3-V)}{C_4H_{10}(g)} + \underset{\frac{13}{2}(3-V)}{\frac{13}{2}O_2(g)} \longrightarrow \underset{4(3-V)}{4CO_2(g)} + 5H_2O(l)$$

$\because$ Total volume of CO_2 produced = 10 L;

$\because \; 3V + 4(3 - V) = 11; \quad \therefore V = 1$

$\therefore$ Volume of butane $= (3 - 1) = 2$L

Thus, the ratio of volume of butane to propane = 2 : 1

117. (c) 

119. (b) Let oxidation state is x;

$$(x + 5 \times 0 + 1) - 2 = 0 \Rightarrow x = +1$$

120. (b) The redox reaction is :

$$Cr_2O_7^{2-} + 3SO_2 + 2H^+ \longrightarrow 2Cr^{3+} + 3SO_4^{2-} + H_2O$$

122. (a) Caro's acid $= H_2SO_5$

= Peroxomono-sulphuric acid

Marshell's acid $= H_2S_2O_8$

= Peroxodi-sulphuric acid

The oxidation state in both the acids is +6 each because oxidation state cannot be greater than the number of valence electrons.

128. (c) 1 mole N_2H_4 loses 8 mole e^-; 1 mole N loses 4 mole of e^-

$\therefore$ New oxidation state of N is $-2 + 4 \Rightarrow 2$

138. (a) The balanced redox reaction is

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

139. (a) Balancing the equation, we have

$$K_2Cr_2O_7 + H_2SO_4 + 3SO_2 \longrightarrow K_2SO_4 + Cr_2(SO_4)_3 + H_2O$$

141. (a) Balanced reaction is

$$PtCl_4 + 5XeF_2 \longrightarrow PtF_6 + 4ClF + 5Xe$$

∴ Sum of stoichiometric coefficients

$$=1+5+1+4+5=16$$

144. (b) $n=|1+5\times 2|$

145. (d) 14 mole HCl^- loses 6 mole e^-;

∴ 1 mole HCl loses $\frac{6}{14}$ mole e^-

$$\therefore \quad \text{eq. wt. of HCl} = \frac{M}{\left(\frac{6}{14}\right)}$$

$$\Rightarrow \quad \frac{36.5\times 14}{6}=85.1$$

146. (d) $n\text{-factor} = \frac{n_1 \times n_2}{n_1+n_2} = \frac{4\times 2}{4+2} = \frac{4}{3}$

$$\text{Eq. wt.} = \frac{\text{mol wt.}}{n\text{-factor}} = \frac{M\times 3}{4}$$

147. (d) $n\text{-factor} = |2\times 2+8\times 3| \Rightarrow 28$

150. (a) $K_2Cr_2O_7 + X^{n+} \longrightarrow X^{5+}O_3^- + Cr^{3+}$

$$6\times 10^{-3}\times 6=(5-n)\times 9\times 10^{-3}\Rightarrow n=1$$

154. (c) $2BrO_3^- + 12H^+ + 10Br^- \longrightarrow 6Br_2 + 6H_2O$

10 mole e^- required for formation of 6 moles of Br_2

$$\therefore \; n\text{-factor of } Br_2 = \frac{10}{6} = \frac{5}{3}$$

$$\text{eq. wt.} = \frac{\text{mol. wt.}}{n} = \frac{m}{5/3} = \frac{3M}{5}$$

156. (a) O.N. of N in N_2H_4 is –2 which changes to 0 in N_2. Hence, equivalent mass of

$$N_2H_4 = \frac{\text{molar mass}}{2\times 2}$$

O.N. of iodine changes from +5 in IO_3^- to +1 in ICl. Hence, equivalent mass of

$$IO_3^- = \frac{\text{molar mass}}{4}$$

163. (c) Eq. mass of $H_2O_2 = \frac{34}{2} = 17$

$$\text{Eq. of } H_2O_2 = \frac{3.4\times x}{100\times 17}$$

$$= \text{Eq. of } KMnO_4 = x\times N\times 10^{-3} \Rightarrow N=2$$

$$\text{Molarity of } KMnO_4 = \frac{2}{5} = 0.4$$

164. (c) 50 m-eq. $KMnO_4$ = 10 m-mole $KMnO_4$ or 25 m-mole of $O_2 = 25\times 22.4\times 10^{-3}$

$$= 0.56 \text{ L}$$

168. (b) Moles of AgCl = moles of $AgNO_3$

$$= \text{moles of HCl} = \frac{0.1435}{143.5} = 10^{-3}$$

wt. of HCl = 0.0365

wt. of $H_2SO_4 = 0.0635$

$$\text{wt. \% of } H_2SO_4 = \frac{.0635\times 100}{0.1} = 63.5$$

169. (b) Eq. wt. of $KBrO_3 = \frac{1}{6}$ of its mol. wt.

$$=\frac{1}{6}\times 167$$

$$N_{Na_2S_2O_3} = \frac{0.167}{167}\times 6\times \frac{1}{0.05} = 0.12N$$

170. (a) Total m-eq. of NaOH taken = 20

m-eq. of H_2SO_4 = m-eq. of NaOH reacted

$$=\frac{5\times 0.2}{25}\times 250 = 10$$

m-eq. of NaOH reacted = 20 – 10 = 10

$$(NH_4)_2SO_4 + 2NaOH$$

$$\Rightarrow \; Na_2SO_4 + 2NH_3 + 2H_2O$$

m-moles of $(NH_4)_2SO_4$ reacted = 5

wt. of $(NH_4)_2SO_4 \Rightarrow 5\times 10^{-3}\times 132 = 0.66$

Percentage of $(NH_4)_2SO_4$ in sample

$$=\frac{0.66}{0.80}\times 100 = 82.5$$

171. (c) milli-equivalent of NH_3 reacted with HNO_3

$$=45\times 0.4 - 20\times 0.1 = 16$$

$$\therefore \; \frac{W}{17}\times 1000 = 16; \quad W_{NH_3} = 0.272\text{ g};$$

$$\text{wt. of N} = 0.272\times \frac{14}{17} = 0.224$$

$$\text{\% N in the sample} = \frac{0.224}{1.12}\times 100 = 20\%$$

172. (a) $1000\times \frac{W}{24+64}\times 2 = 90\times \frac{1}{100}\times 5;$

$$W = 0.198 \text{ g}$$

% of oxalate ion in a given sample

$$=\frac{0.198}{0.3}\times 100 = 66$$

173. (a) m-moles of HCl = $20\times 0.1 = 2$

m-moles of MgO reacted with HCl = $\frac{2}{1} \Rightarrow 1$

wt. of MgO present = 1×40 mg

$$\therefore \; \text{\% of MgO} = \frac{40}{320} = 12.5\%$$

174. (c) $Pb^{2+} + SO_4^{2-}$ (from Na_2SO_4) $\longrightarrow PbSO_4$

moles of Na_2SO_4 req. = moles of Pb^{2+} ions

$$= \frac{0.355}{142} = 0.0025$$

$$[Pb^{2+}] = \frac{0.0025}{0.50} = 5 \times 10^{-3}\ M$$

175. (b) Let volume of HNO_3 is V then

$$V \times 1.05 \times \frac{12.6}{100} \times \frac{3}{63} = \frac{1}{278} \times 1$$

$$V = 0.57 \text{ mL}$$

176. (c) m-eq. of $KMnO_4$ = m-eq. of FeC_2O_4 + m-eq. of $FeSO_4$

$$(0.1 \times 5) \times V = \frac{100}{\frac{144}{3}} + \frac{100}{\frac{152}{1}};$$

$$V = 5.48 \text{ mL}$$

177. (a) meq. $FeSO_4\,(NH_4)_2SO_4 \cdot 6H_2O$ = meq of $KMnO_4$

$(n = 1)$

$$\frac{W}{392} \times 1 \times 1000 = 0.1 \times 50; \quad W = 1.96\text{ g}$$

Hence, % purity of Mohr's salt

$$= \frac{1.96}{2.5} \times 100 = 78.4\%$$

178. (d) $Cr_2O_7^{2-} + 6Fe^{2+}$ $(n = 1)$ (Mohr's salt) $+ 14H^+ \longrightarrow 2Cr^{3+} + 6Fe^{3+} + 7H_2O$

Equivalent of Fe^{2+} = moles of Mohr's salt
= equivalent of $K_2Cr_2O_7$
$= 500 \times 10^{-3} \times 6 \times 1 = 3.0$

Hence, mole per cent of Mohr's salt

$$= \frac{3}{4} \times 100 = 75$$

180. (d) $X_2O_3 \longrightarrow 2X^{3+} + 3O^{2-}$

i.e., the valency of metal in oxide is 3

∵ 6 mg $= 6 \times 10^{-3}$ g of H_2 reacts with X_2O_3

∴ 1 g or 1 equivalent of H_2 reacts with $X_2O_3 = 0.1596$ g

$$\therefore \text{ Equivalent of } X_2O_3 = \frac{0.1596}{6 \times 10^{-3}} = 26.6\text{ g};$$

∴ Equivalent weight of $X_2O_3 = 26.6$
= Equivalent weight of X
+ Equivalent weight of O $= E + 8$

$\Rightarrow \quad E + 8 = 26.6; \quad \Rightarrow \quad E = 18.6$

∵ At. wt. = Eq. wt. × Valency

$$= 18.6 \times 3 = 55.8$$

181. (b) Let normality of $KMnO_4$ solution is N

$\therefore \ N \times 10 = 50 \times 1 \quad \Rightarrow \quad N = 5$

m-eq. of MnO_4^- = m-eq. of oxalic acid

$$= N_1V_1 = \frac{W}{E} \times 1000$$

$$5 \times 100 = \frac{W}{(90/2)} \times 1000 \Rightarrow W = 22.5\text{ g}$$

182. (d) Let the moles of $NaHC_2O_4$ be 'a' and that of $KHC_2O_4 \cdot H_2C_2O_4$ be 'b' and volumes of each consumed be V litre.

In redox :

when $KMnO_4$ used : $0.2 \times V = 2a + 4b$ ...(1)

In acid-base neutralization :

when NaOH used: $0.12 \times V = a + 3b$ ...(2)

from (1) and (2) $a = 0.06\,V$

$b = 0.02\,V$ or $a : b = 3 : 1$

184. (d) eq. wt. of $NaHC_2O_4$ as an acid = 112

eq. of $NaHC_2O_4$ = eq. of NaOH
$= 100 \times 10^{-3} \times 0.2$
$= 0.02$

$\Rightarrow \quad a = 0.02 \times 112 = 2.24$ g

eq. wt. of $NaHC_2O_4$ as reductant

$$(C_2O_4^{2-} \longrightarrow 2CO_2 + 2e^-) = \frac{112}{2} = 56$$

eq. of $NaHC_2O_4$ as reductant = eq. of $KMnO_4 = 100 \times 10^{-2} \times 0.02 \times 5 = 0.01$

$\Rightarrow \quad b = 0.01 \times 56 = 0.56$ g

$$\text{Hence, } a : b = \frac{2.24}{0.56} = 4 : 1 \text{ or } a = 4b$$

185. (c) eq. of $Na_2C_2O_4$ + eq. of $H_2C_2O_4$
= eq. of $KMnO_4 = V \times 0.1 \times 5$

$2 + 2 = 0.5\,V; \qquad V = 8$L

eq. of $H_2C_2O_4$ = eq. of NaOH

$\Rightarrow \ 1 \times 2 = 0.2 \times V_2; \quad V_2 = 10$ L

Hence, $V_1 : V_2 = 8 : 10 = 4 : 5$

186. (a) eq. wt. of $K_2C_2O_7 = \frac{\text{molar mass}}{6}$

eq. wt. of $KMnO_4 = \frac{\text{molar mass}}{5}$

eq. of $Na_2S_2O_3$ = eq. of I_2 liberated
= eq. of $KMnO_4$ + eq. of $K_2Cr_2O_7$

or $N \times 1 = 0.02 \times 5 + 0.05 \times 6$

$\Rightarrow \quad N = 0.4$ or $M = 0.4$

187. (b) m-eq. of acid's in 50 mL = m-eq. of Na_2CO_3

$$25\times2+50\times4+2\times2\times x=\frac{1000}{50}\times25\times1$$

$x = 62.5$ mL

188. (d) Moles of pure $CuSO_4 = 0.12 =$ moles of $Na_2S_2O_3$ reacted with I_2

Moles of $Na_2S_2O_3 = 120\times10^{-3}\times M$

$= 0.12$

$M = 1.0$

189. (d) Let x g of Li_2CO_3 and $(1-x)$ g of M_2CO_3 present in given mixture

$2\times$Total moles of carbonates = moles of HCl and

$$2\times\left(\frac{x}{74}+\frac{1-x}{2M+60}\right)=21.6\times0.5\times10^{-3}$$

$$x = 0.407$$

$$\because \quad \frac{x}{74}=\frac{1-x}{2M+60}$$

$$M = 51$$

190. (b) m-eq. of $FeSO_4{\cdot}7H_2O$ in 1 litre

$$=20\times0.02\times5\times\left(\frac{1000}{25}\right)=80$$

$$\therefore \quad \frac{W}{278}\times1\times1000=80\Rightarrow W=22.24$$

weight % of $FeSO_4{\cdot}7H_2O$ in given sample

$$=\frac{22.24}{32}\times100=69.5$$

191. (a) Since, phenolphthalein indicates only conversion of Na_2CO_3 into $NaHCO_3$ hence, x mL, of HCl will be further required to convert $NaHCO_3$ to H_2CO_3. So, total volume of HCl required to convert Na_2CO_3 into $H_2CO_3 = x + x = 2x$ mL

193. (c) Phenolphthalein gives the end point corresponding to the reactions :

$$NaOH + HCl \longrightarrow NaCl + H_2O$$

$$Na_2CO_3 + HCl \longrightarrow NaHCO_3 + NaCl$$

$\therefore$ m-moles of NaOH + m-moles of Na_2CO_3

= moles of HCl $= 2.5$

Methyl orange gives the end point corresponding to the reactions :

$$NaOH + HCl \longrightarrow NaCl + H_2O$$

$$Na_2CO_3 + 2HCl \longrightarrow 2NaCl + CO_2 + H_2O$$

$\therefore$ m-moles of NaOH

+ m moles of $Na_2CO_3\times2$

= m-moles of HCl $= 30\times0.1 = 3$

milli-moles of $Na_2CO_3 = 0.5$

m-mole of NaOH $= 2.5 - 0.5 = 2$

Ratio of mole of NaOH and Na_2CO_3

$$=\frac{2}{0.5}=4:1$$

196. (a) $Na_2CO_3 + 2HCl \longrightarrow 2NaCl + H_2O + CO_2$

At the equivalent point m-mole of HCl

$= 2\times$ m-mole of Na_2CO_3

$$60\times M=2\times\frac{0.318}{106}\times1000$$

$$M = 0.1$$

198. (c) Milli-equivalents of Ca^{2+}

+ milli-equivalents of Mg^{2+}

= milli-equivalents of Na_2CO_3

$$\frac{20}{20}+\frac{12}{12}=V\times2$$

$\therefore$ $V = 1$ mL for 1 L of tap water

For 5000 L of pond water

$V = 5000$ mL or 5 L

199. (d) 4.44 mg $CaCl_2$ is equivalent to 4 mg $CaCO_3$

1.9 mg $MgCl_2$ is equivalent to 2 mg $CaCO_3$

Total wt. of $CaCO_3 = 6$ mg

$$\text{Hardness in ppm}=\frac{6\times10^{-3}}{10^3}\times10^6$$

$= 6$ ppm

Level 2

1. (a) Let wt. of NH_4NO_3 and $(NH_4)_2HPO_4$ are x and y gram respectively

$$\frac{\frac{x}{80}\times2\times14+\frac{y}{132}\times2\times14}{x+y}\times100=30.4$$

$\Rightarrow \quad x : y = 2 : 1$

2. (a) Let V mL of alcohol be required

$\because$ mass of alcohol is same in both solutions

$$\therefore \quad \frac{75}{100}\times0.8\times V=\frac{30}{100}\times0.9\times150$$

$V = 67.5$ mL

3. (d) The precipitation reaction is

$$Fe^{3+} + 3NH_3 + 3H_2O \longrightarrow Fe(OH)_3 + 3NH_4^+$$

$$\text{mole of } Fe_2O_3 \text{ in sample}=\frac{0.80\times0.5}{160}$$

$= 2.5\times10^{-3}$

mole of $Fe^{3+} = 2 \times 2.5 \times 10^{-3} = 5 \times 10^{-3}$

$$M_{NH_3} = \frac{0.986\ g/mL \times 1000\ mL/litre \times 0.025}{17}$$

$\Rightarrow \quad M_{NH_3} = 1.45$

$3 \times$ moles of Fe^{3+} = moles of NH_3

$\Rightarrow 1.45 \times V$ (inL)

$$V = \frac{3 \times 5 \times 10^{-3}}{1.45} = 10.34 \times 10^{-3}\ L \text{ or } 10.34\ mL$$

4. (a) Balanced reaction is

$$2F_2O_3 + 3C \longrightarrow 4Fe + 3CO_2$$

No. of moles of $Fe_2O_3 = \left(\frac{120 \times 1000}{2 \times 56 + 48}\right) \times \frac{90}{100}$

Mass of 80% pure iron produced

$$= \frac{120 \times 1000 \times 0.9}{2 \times 56 + 48} \times \frac{2 \times 56}{0.8}$$

$= 94500$ gram or 94.5 kg

5. (d) Let two equimolar carbonates are ACO_3 and BCO_3

Wt. of metal $A = 2.8 \times 0.125 = 0.35\,g$

$$ACO_3 + BCO_3 \longrightarrow AO + BO + 2CO_2$$

Total two moles CO_3^{2-} provide 2 moles of CO_2 or 60 g CO_3^{2-} provide 44 g of CO_2

Total mass of CO_3^{2-} required to produced 1.32 g of $CO_2 = \frac{60}{44} \times 1.32 = 1.8\,g$

wt. of metal $(A + B) = 2.8 - 1.8 = 1\,g$

wt. of $B = 1 - 0.35 = 0.65\,g$

$$\%\text{ of } B = \frac{0.65}{2.80} \times 100 = 23.21$$

6. (b) Loss in wt. due to heating $= 6.2 \times \frac{5}{100}$

$= 0.31\,g$

$$\underset{2 \times 84\,g}{2NaHCO_3} \longrightarrow Na_2CO_3 + \underset{44\,+}{CO_2} + \underset{18\,g\ \text{loss}}{H_2O}$$

1 mole $NaHCO_3 \longrightarrow$ 31 g loss due to heating

0.31 g loss from 0.01 mole of $NaHCO_3$

Moles of Na_2CO_3 produced $= \frac{0.01}{2} = 0.005$

Total moles of carbonate reacted with $BaCl_2$

$$= \left(7.5 \times 0.2 \times \frac{100}{10}\right) \times 10^{-3} = 0.015$$

Moles of carbonates in original sample

$= 0.015 - 0.005 = 0.01$

Mass of Na_2CO_3 in original sample

$= 0.01 \times 106 = 1.06$ gram

7. (c) Moles of NO_2 required

$$= \left(\frac{1575}{63}\right) \times \frac{3}{2} \times \frac{1}{0.8} = 46.875$$

moles of NO required $= \frac{46.875}{0.60}$

moles of NH_3 required $= \frac{46.875}{0.60} \times \frac{1}{0.50}$

$= 156.25$

Volume of NH_3 at STP required

$= 156.25 \times 22.4 = 3500$ L

8. (c) Moles of NaOH consumed when reacted with $H^+ = 3 \times 1$

moles of H_2SO_4 present in sample $= 1.5$

wt. of H_2SO_4 in sample $= 1.5 \times 98 = 147$ g

$$\%\text{ purity} = \frac{147}{183.75} \times 100 = 80$$

9. (c) Let wt. of sample is x g; wt. of MnO_2 is $0.75\,x$ g

moles of $MnO_2 = \frac{0.75x}{87}$

wt. of Mn $= \frac{0.75x}{87} \times 55 = 0.474x$

$$3MnO_2 \longrightarrow Mn_3O_4 + O_2$$

wt. of Mn_3O_4 produced

$$= \frac{0.75x}{87} \times \frac{1}{3} \times 229 = 0.658x\ g$$

Total wt. of residue $= 0.658x + 0.2x$ (wt. of impurities)

% of Mn in residue $= \frac{0.474x}{0.858x} \times 100$

$= 55.24$

10. (b) Moles of AgCl = moles of chloride

$$= \frac{1.96}{143.5} = 0.0136$$

Moles of organic compound $= \frac{1}{147}$

$= 6.8 \times 10^{-3}$

Chlorine atoms in each molecule of organic compound $= \frac{0.0136}{6.8 \times 10^{-3}} = 2$

11. (c) Let x g is wt. of CaC_2O_4 and $(0.6 - x)$ g wt. of MgC_2O_4

$$CaC_2O_4 \xrightarrow{\Delta} CaCO_3 + CO_2$$

$$MgC_2O_4 \xrightarrow{\Delta} MgCO_3 + CO_2$$

$$\text{wt. of } CaCO_3 \text{ produced } = \frac{x}{128} \times 100$$

$$\text{wt. of } MgCO_3 \text{ produced} = \frac{(0.6 - x)}{112} \times 84$$

$$\therefore \frac{x}{128} \times 100 + \frac{(0.6 - x)}{112} \times 84 = 0.465$$

$$x = 0.48 \text{ g}$$

Due to further heating

$$\begin{array}{lcl} CaCO_3 & \xrightarrow{\Delta} & CaO + CO_2 \\ - & & \frac{x}{128} \end{array}$$

$$\begin{array}{lcl} MgCO_3 & \xrightarrow{\Delta} & MgO \quad + CO_2 \\ - & & \left(\frac{0.6 - x}{112}\right) \end{array}$$

wt. of CaO and MgO produced

$$= \frac{0.48}{128} \times 56 + \frac{0.12}{112} \times 40 = 0.252 \text{g}$$

12. (a) Moles of $BaSO_4 = \frac{1.22}{233.3}$

$$\text{moles of } M_2(SO_4)_3 = \frac{1.22}{233.3} \times \frac{1}{3}$$

$$= 1.743 \times 10^{-3}$$

$$\text{wt. of } M_2(SO_4)_3 = 0.596$$

$$\therefore 1.743 \times 10^{-3} (2M + 96 \times 3) = 0.596$$

$$M = 26.9$$

13. (b) $2NH_3 + CO_2 \longrightarrow NH_2{-}CO{-}NH_2 + H_2O$

$$\text{moles of urea} = \frac{999.6 \times 10^3}{60} = 16.66 \times 10^3$$

$$\therefore \text{ moles of } CO_2 = 16.66 \times 10^3$$

$$C_nH_{2n+2} + O_2 \longrightarrow nCO_2 + H_2O$$

$$\frac{16.66 \times 10^3}{n} \times [12n + (2n + 2)] = 236 \times 10^3$$

$$n \cong 12$$

∴ molecular formula of hydrocarbon

$$= C_{12}H_{26}$$

14. (d) $C_nH_{2n+2} + \left(\frac{3n+1}{2}\right) O_2 \longrightarrow nCO_2 + (n+1) H_2O$

Let initial pressure of C_nH_{2n+2} is P then increase in pressure

$$= P\left[(2n + 1) - 1 - \left(\frac{3n+1}{2}\right)\right]$$

$$= \left(\frac{n-1}{2}\right) P$$

546 K and 4.6 atm ⟶ 273 and 2.3 atm;
Increase in pressure = 0.3 atm

$$P = \frac{nRT}{V} = \frac{11.6}{M} \times \left(\frac{0.0821 \times 273}{22.41}\right)$$

$$\left(\frac{n-1}{2}\right) \times \frac{11.6}{(14n + 2)} = 0.3$$

$$\left(\frac{n-1}{14n + 2}\right) = \frac{0.6}{11.6} = n = 4$$

∴ Compound is C_4H_{10}

15. (d) Mole of $H_2SO_4 = 0.1$; mole of $KOH = 0.2$

mole of H_2O_2 used in first reaction

$$= \frac{0.2}{2} \times \frac{1}{0.4} = 0.25$$

$$\text{mole of produced } O_2 = \frac{6.74}{22.4} = 0.3$$

∴ mole of H_2O_2 used in second reaction

$$= \frac{0.3}{3 \times 0.5} = 0.2$$

Total mole of consumed $H_2O_2 = 0.45$

$$\text{Molarity of } H_2O_2 = \frac{0.45}{0.15} = 3M$$

Volume strength = 11.2 × 3 = 33.6 volumes

16. (b) $SO_2Cl_2 + 2H_2O \longrightarrow H_2SO_4 + 2HCl$

m-moles of H_2SO_4 produced = 5; m-moles of HCl produced = 10

m-moles of $Ba(OH)_2$ required

$$= 5 \text{ (for } H_2SO_4) + \frac{10}{2} \text{ (for HCl)} = 10$$

$$\therefore M \times V = 10, 0.2 \times V = 10, V = 50 \text{ mL}$$

17. (b) Only Na_2CO_3 is reacted with H_2SO_4;

$$Na_2CO_3 + H_2SO_4 \longrightarrow Na_2SO_4 + H_2CO_3$$

m-moles of Na_2CO_3 = m-moles of H_2SO_4

$$= 20 \times 0.1 = 2$$

m-moles of Na_2CO_3 in 250 mL solution

$$= \frac{250}{25} \times 2 = 20$$

$$\text{wt. of } Na_2CO_3 = 20 \times 106 \times 10^{-3} = 2.12 \text{g}$$

$$\% \text{ of } Na_2CO_3 = \frac{2.12}{5} \times 100 = 42.4$$

$$\therefore \% \text{ of } Na_2SO_4 = 100 - 42.4 = 57.6$$

18. (a) M_{NaOH} resultant

$$= \frac{20 \times 0.2 + 35 \times 0.1}{100} = 0.075M$$

Milli-equivalent of NaOH = milli-equivalent of $H_2C_2O_4$

Let wt. of impure sample is x gram

$$40 \times 0.075 = \frac{x \times 0.90}{90} \times 2 \times 1000$$

$$x = 0.15 \text{ gram}$$

19. (b) $Ag + HNO_3 \longrightarrow AgNO_3$

$AgNO_3 + NaCl \longrightarrow NaNO_3 + AgCl$

POAC on Ag

Mole of Ag in coin = mole of Ag in AgCl

$$a = \frac{14.35}{143.5} = 0.1 \text{ mole}$$

Mass of Ag in coin $= 0.1 \times 108 = 10.8$ g

$\therefore$ % silver in coin $= \frac{10.8}{11.34} \times 100\% = 95.2\%$

20. (c) Mass ratio of Y in compound A, B and C is 1 : 3 : 5, in compound B, 32 parts of X combine with 84 parts of Y

$\therefore$ 16 parts of X combine with 42 parts of Y

For Y 3 parts in compound B, then in compound C = 5 parts

$\therefore$ 42 parts in compound B, then in the compound $C = \frac{5}{3} \times 42 = 70$ parts

21. (a) Mole of $O_2 = \frac{67.2}{22.4} = 3$ mole

$$3O_2 \rightarrow 2O_3$$

$\therefore$ Mole of Ozone formed $= \frac{2}{3} \times \frac{15}{100} \times 3$

$= 0.3$ mole

$\therefore$ Mass of Ozone formed $= 0.3 \times 48$ g $= 14.4$ g

22. (a) $[H^+] = 10^{-3}\ M$

So $[Ca^{2+}] = \frac{1}{2} \times 10^{-3}\ M$

wt. of $Ca^{2+} = \frac{10^{-3}}{2} \times 40$

So, weight of Ca^{2+} ions in 10^6 mL hard water $= \dfrac{\frac{1}{2} \times 10^{-3} \times 40 \times 10^6}{10^3} = 20$

23. (a) m-eq. of acid = m-eq. of base

$\therefore$ $N_1V_1 = N_2V_2$

$$\frac{29.4}{\left(\frac{98}{n}\right)} \times 100 = 90 \times \left(\frac{20}{40} \times \frac{1000}{500}\right)$$

$$n = 3$$

24. (b) When phenolphthalein is used as an indicator : $0.05\,x = 20 \times 0.1 \times 1$; $x = 40$ mL

When methyl orange is used as an indicator:

$$0.05\,y = 20 \times 0.1 \times 3$$

$$y = 120 \text{ mL}$$

$$\therefore \quad y - x = 80 \text{ mL}$$

25. (a) $I_2 + AsO_2^- + 2H_2O \longrightarrow HAsO_4^{2-} + 2I^- + 3H^+$

m-eq. of $HAsO_2$ (in 50 mL) = m-eq. of I_2

$= 35 \times 0.05 \times 2 = 3.5$

m-eq. of $HAsO_2$ in 250 mL $= 3.5 \times \frac{250}{50}$

$= 17.5$

wt. of $HAsO_2$ in sample

$= \frac{17.5}{2} \times (108) \times 10^{-3} = 0.945$ g

% of $HAsO_2$ in the sample $= \frac{0.945}{3.78} \times 100$

$= 25\%$

26. (a) m-eq. of FeO = m-eq. of $KMnO_4$

$= 0.25 \times 5 \times 100$

m-mole of FeO $(n = 1) = \frac{0.25 \times 100 \times 5}{1}$

$= 125$

total m-eq. or m-mole. of Fe^{2+}

$= 1000 \times 0.1 \times 6 = 600$

(from FeO and Fe_2O_3 after reaction with Zn dust)

m-mole of Fe^{2+} from $Fe_2O_3 = 600 - 125$

$= 475$

m-mole of $Fe_2O_3 = \frac{475}{2}$

wt. of FeO $= \frac{125 \times (56 + 16)}{1000}$ g $= 9$ g

wt. of $Fe_2O_3 = \frac{475}{2} \times \frac{160}{1000} = 38$ g

% $Fe_2O_3 = \frac{38}{38 + 9} \times 100 = 80.85\%$

27. (d) $3Br_2 + 6OH^- \longrightarrow 5Br^- + BrO_3^- + 3H_2O$ ...(1)

$6H^+ + BrO_3^- + 3C_2O_4^{2-} \longrightarrow Br^- + 6CO_2 + 3H_2O$ ...(2)

10 m-mole of Br_2 produce (10/3) m-mole BrO_3^- and required m-moles of

$$CaC_2O_4 = \frac{10}{3} \times 3 = 10$$

$\therefore$ wt. of $CaC_2O_4 = 10 \times 10^{-3} \times 128$

$$\% \text{ purity} = \frac{10 \times 10^{-3} \times 128}{2} \times 100 = 64$$

28. (b) m-moles of KI $= 50 \times 0.04 = 2$

m-equivalent of $Na_2S_2O_3$ reacted with 10 mL solution $= 20 \times 2.5 \times 10^{-3} = 50 \times 10^{-3}$

m-equivalent of I^- left unreacted in 100 mL solution $= 50 \times 10^{-3} \times \frac{100}{10} = 0.5$

m-moles of I^- reacted with $CuCO_3 = 2 - 0.5$
$= 1.5$

$\because \quad 2Cu^{2+} + 5I^- \longrightarrow 2CuI + I_3^-$

m-moles of $Cu^{2+} = \frac{2}{5} \times 1.5 = 0.6$

weight of $CuCO_3 = 0.6 \times 10^{-3} \times 123.5$
$= 0.0741$

$$\text{weight \% of } CuCO_3 = \frac{0.0741}{0.1} \times 100$$
$$= 74.1$$

29. (b) $\underset{(n\,=\,6)}{Fe_2(C_2O_4)_3} + \underset{(n\,=\,5)}{MnO_4^-} + H^+ \longrightarrow 2Fe^{3+} + 6CO_2 + H_2O$

$\underset{(n\,=\,3)}{FeC_2O_4} + \underset{(n\,=\,5)}{MnO_4^-} + H^+ \longrightarrow Fe^{3+} + 2CO_2 + H_2O$

Total equivalents of $(Fe_2(C_2O_4)_3 + FeC_2O_4)$
= equivalents of $KMnO_4$

$\therefore \quad 0.5 \times 6 + 0.5 \times 3 = x \times 5$

moles of $KMnO_4 = x = 0.9$

30. (b) m-eq. of $Na_2C_2O_4$ = m-eq. of $KMnO_4$ reacted

total m-eq. of $KMnO_4$– excess m-eq. of $KMnO_4$ reacted with $H_2C_2O_4$
$= 45 \times 0.02 \times 5 - 10 \times 0.1 \times 2 = 2.5$

$$1000 \times \frac{W}{134} \times 2 = 2.5$$

$$W_{Na_2C_2O_4} = 0.1675\,g$$

% purity of $Na_2C_2O_4$ in sample

$$= \frac{0.1675}{0.2} \times 100 = 83.75$$

31. (a) Reactions of $K_2Cr_2O_7$ and $KMnO_4$ with KI may be given as :

$K_2Cr_2O_7 + 7H_2SO_4 + 6KI \longrightarrow 4K_2SO_4 + Cr_2(SO_4)_3 + 7H_2O + 3I_2$

$2KMnO_4 + 8H_2SO_4 + 10KI \longrightarrow 6K_2SO_4 + 2MnSO_4 + 5I_2$

Thus, equivalent wt. of $K_2Cr_2O_7 = \frac{294}{6} = 49$

equivalent wt. of $KMnO_4 = \frac{158}{5} = 31.6$

$\because$ m-eq. of $K_2Cr_2O_7$ + m-eq. of $KMnO_4$
= meq. of I_2 = m-eq. of hypo.

Let the mass of $K_2Cr_2O_7 = x$ g;

$\therefore$ mass of $KMnO_4 = (0.5 - x)$ g

$$\frac{x}{49} + \frac{(0.5 - x)}{31.6} = 150 \times 0.1 \times 10^{-3}$$

or $\quad x = 0.0732$

$$\therefore \quad \% \text{ of } K_2Cr_2O_7 = \frac{0.0732}{0.5} \times 100$$

$\Rightarrow 14.64$

32. (b) $I_2 + 2Na_2S_2O_3 \longrightarrow 2NaI + Na_2S_4O_6$ ...(i)

m-moles of $Na_2S_2O_3$ consumed
$= 15 \times 0.4 = 6$ m-mole

m-moles of I_2 consumed = 3 m-mole

$3I_2 + 6NaOH \longrightarrow 5NaI + NaIO_3 + 3H_2O$ ...(ii)

m-mol of I_2 reacted with NaOH are

$$= \frac{30 - 2 \times 3}{2} = 12 \text{ m-mole}$$

Total m-mole of I_2 consumed in reaction (i) and (ii) $= 3 + 12 = 15$ m-mole

$$\text{Molarity of } I_2 = \frac{15}{150} = 0.1\,M$$

33. (a) Let x and y are milli-moles H_2SO_4 and $H_2C_2O_4$ in given mixture when both reacted with base

m-eq. of acids = m-eq. of base;

$$(x + y) \times 2 = 3 \times 0.1 \times \frac{1000}{10} \quad \text{or} \quad x + y = 15$$

In second experiment only $KMnO_4$ reacted with $H_2C_2O_4$ in which Mn^{7+} converted into Mn^{2+} and $C_2O_4^{2-}$ converted into CO_2

$\therefore$ milli-equivalent of $H_2C_2O_4$
= milli-equivalent of $KMnO_4$

$$y \times 2 = 4 \times 0.02 \times 5 \times \frac{1000}{100}$$

$$y = 2$$

$\therefore \; x = 13$, wt. of $H_2SO_4 = 13 \times 10^{-3} \times 98$

$$= 1.274\ \text{g}$$

$\therefore$ wt. % of H_2SO_4 in sample $= \dfrac{1.274}{3.185} \times 100$

$$= 40\%$$

35. (c) $KMnO_4 + C_2O_4^{2-} \xrightarrow{H^+} Mn^{2+} + CO_2$

$n_f = 5$ $\quad n_f = 2$

16 mL $\quad$ 40 mL

0.05 M $\quad$ XM

Milliequiv. of $C_2O_4^{2-}$ = milliequiv. of $KMnO_4$

$2(40)X = 5 \times 16 \times 0.05$

$X = 0.05M$

$\therefore\ [H^+] = 2X = 0.1\ M$

pH = 1

Level 3

Passage-1

1. (b) $H_2O + SO_3 \longrightarrow H_2SO_4$;

18 g water combines with 80 g SO_3

$\therefore$ 4.5 g of H_2O combines with 20 g of SO_3.

$\therefore$ 100 g of oleum contains 20 g of SO_3

or 20% free SO_3.

2. (c) Initial moles of free SO_3 present in oleum

$$= \frac{12}{18} = \frac{2}{3}\ \text{moles}$$

= moles of water that can combines with SO_3

moles of free SO_3 combined with water

$$= \frac{9}{18} = \frac{1}{2}\ \text{mole}$$

moles of free SO_3 remains $= \dfrac{2}{3} - \dfrac{1}{2} = \dfrac{1}{6}$ mole

$\therefore$ volume of free SO_3 at STP $= \dfrac{1}{6} \times 22.4$

$$= 3.73\ \text{L}$$

3. (c) $Na_2CO_3 + H_2SO_4 \longrightarrow Na_2SO_4 + H_2O + CO_2$.

moles of CO_2 formed = moles of Na_2CO_3 reacted $= \dfrac{5.3}{106} = 0.05$

volume of CO_2 formed at 1 atm pressure and 300 K $= 0.05 \times 24.63 = 1.23$ L

4. (b) eq. of H_2SO_4 + eq. of SO_3 = eq. of NaOH

$$\frac{x}{98} \times 2 + \frac{(1-x) \times 2}{80} = 54 \times 0.4 \times 10^{-3}$$

$$x = 0.74$$

$$\%\ \text{of free } SO_3 = \frac{1 - 0.74}{1} \times 100 = 26\%$$

Passage-2

1. (a) 1 litre of $H_2O_2(aq)$ provide 11.2 litre of O_2 at STP

moles of $O_2 = \dfrac{11.2}{22.4} = 0.5$

$n_{H_2O_2}$ required $= 0.5 \times 2$

$$M_{H_2O_2} = \frac{n_{H_2O_2}}{V_{\text{solution}}} = 1\ M$$

2. (b) Strength in percentage means how many g H_2O_2 present per 100 mL

$\because$ $M \Rightarrow$ 1 and mol. wt. of $H_2O_2 = 34$

$\therefore$ 34 g H_2O_2 present per litre of solution or 3.4 g H_2O_2 present per 100 mL of solution.

3. (b) m-eq. of H_2O_2 = m-eq. of $KMnO_4$

$20 \times N = 0.05 \times 5 \times 80 \Rightarrow N = 1$

$$N = \frac{\text{volume strength of } H_2O_2}{5.6}$$

$\Rightarrow$ volume strength of $H_2O_2 = 5.6$

4. (b) m-eq. of $Ba(MnO_4)_2$ = m-eq. of H_2O_2

$$\left(\because M = \frac{33.6}{11.2} \Rightarrow 3\right)$$

$\dfrac{w}{375} \times 10 \times 1000 = 3 \times 125 \times 2$; $\quad w = 28.125$

$$\%\ \text{purity} = \frac{w}{40} \times 100$$

$$= \frac{28.125}{40} \times 100 = 70.31$$

Passage-3

1. (c) 136 mg of $CaSO_4 \equiv 100$ mg of $CaCO_3$;

190 mg of $MgCl_2 \equiv 2 \times 100$ mg of $CaCO_3$

1 litre of 1000 g water contain 300 mg of $CaCO_3$

10^6 g water contain

$$\frac{300 \times 10^{-3}}{1000} \times 10^6 = 300\ \text{ppm}$$

2. (b) 10^6 g water contain 100 g $CaCO_3$

10 L or 10^4 g water contain

100 g $CaCO_3 \equiv 162$ g of $Ca(HCO_3)_2$

or 1 g $CaCO_3 \equiv 1.62$ g of $Ca(HCO_3)_2$

or 0.01 mole

$$Ca(HCO_3)_2 + Ca(OH)_2 \longrightarrow 2CaCO_3 \downarrow + 2H_2O$$

moles of $Ca(OH)_2$ required = 0.01

or wt. of $Ca(OH)_2$ required = 0.74 g

3. (b) m-moles of H^+ present in outlet water

= m-moles of $OH^- = 50 \times 0.1 = 5$

m-moles of Ca^{2+} present in hard water $= \frac{5}{2}$

= 2.5; (1 Ca^{2+} replaced by $2H^+$)

no. of mg of Ca^{2+} ion $= 2.5 \times 40 = 100$

200 g sample hard water contain 100 mg of Ca^{2+}

$\therefore$ 10^6 g sample hard water contain

$$\frac{100}{200} \times 10^6 \times 10^{-3} = 500 \text{ ppm}$$

Passage-4

1. (c) n-factor $= 5 \times 2 = 10$

2. (a) H_3PO_2 is a monobasic acid $\therefore$ n-factor = 1

3. (a) n-factor $= \left(3 - \frac{2}{0.95}\right) \times 0.95 = 0.85$

$$\therefore E = \frac{M}{0.85}$$

4. (b) n-factor of VO = 3; $Fe_2O_3 = 1 \times 2 = 2$;

$\therefore$ x and y are 2 and 3

One or More Answers is/are Correct

11. (a,c,d) $V_{strength} = 56$;

$$\therefore M = \frac{28}{11.2} = 2.5$$

$\therefore$ 1 L contain 2.5 moles of H_2O_2

or $2.5 \times 34 = 85$ g H_2O_2

wt. of 1 litre solution = 265 g

($\because$ $d = 265$ g/L)

$\therefore$ $w_{H_2O} = 180$ g or moles of $H_2O = 10$

$$x_{H_2O_2} = \frac{2.5}{2.5 + 10} = 0.2$$

$$\% \frac{w}{v} = \frac{2.5 \times 34}{1000} \times 100 = 8.5$$

$$m = \frac{2.5}{180} \times 1000 = 13.88$$

14. (b,c,d) $3Sn^{2+} + 14H^+ + Cr_2O_7^{2-} \longrightarrow 3Sn^{3+} + 2Cr^{3+} + 7H_2O$

Match the Column

3. Use % by moles $= \frac{M_{avg} - M_1}{M_2 - M_1} \times 100$

% by mass = % by moles $\times \frac{M_2}{M_{avg}}$