CTEVT, DIPLOMA, QUESTION & SOLUTION

⇐ SECOND EDITION ⇒

Engineering Chemistry-I

(for Diploma I Yrs. I Part)

First Semester

(Engineering All)

By

Arjun Chaudhary

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Authors **© Arjun Chaudhary**

Email:- info@arjun00.com.np

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S.No	Exam Year,	Month
1.	2076	Falgun Regular/Back
2.	2078	Bharda Regular/Back
3.	2079	Ashad Regular (2021 New)
4.	2079	Ashad Back (Old)
5.	2080	Baishakh Back (Old)
6.	2080	Baishakh Regular (2021 New)
7.	2080/81	Chaitra Back (Old)
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Engineering Chemistry I__(Engg. All) $1^{st\ Sem}$

(2076) Question Paper Solution.

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1. a) Write the qualitative and quantitative significance of following chemical equation.

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

➢ **Balancing the Give Equation:**

$NaOH$	$+$	H_2SO_4	$\longrightarrow$	Na_2SO_4	$+$	H_2O
2 mole		1 mole		1 mole		2 mole
2×40gm		98gm		142gm		2×18gm

➢ **Qualitative Significance :**

- ✓ Sodium hydroxide and sulphuric acid are reactants. Sodium sulphate and water are the products.
- ✓ Sodium hydroxide reacts with Sulphuric acid to give sodium sulphate and water.

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➢ **Quantitative Significance :**

- ✓ 2 mole of $NaOH$ reacts with 1 mole of H_2SO_4 to produce 1 mole of $Na_2SO_4$and 2 mole of H_2O.
- ✓ 80gm of of $NaOH$ reacts with 98gm of H_2SO_4 to give 142gm of Na_2SO_4 and 36gm of H_2O.

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b) Define equivalent weight. 0.175 gm of a metal gave 152 ml of H_2 at NTP on treatment with dil. H_2SO_4. Calculate the equivalent wt of metal.

- **Equivalent weight** is the amount of a substance that will react with or replace one equivalent of another substance in a chemical reaction. It is calculated by dividing the molecular weight of the substance by the number of equivalents it can produce or react with.

- **Solution :**

Weight of metal (w) = 0.175gm

Volume of H_2 produced at NTP (V) = 152 ml

We have,

At NTP,

(Standard Value) density of H_2 $(\rho) = 0.089\ gm/l$

$= 0.089 \times 10^{-3}\ g/m^3$

Weight of H_2 $(W_1) = \rho V$

$= 0.089 \times 10^{-3} \times 152$

$= 0.0135\ gm$

And

Eq. wt of H_2 = 1.008 (Standard Valve)

We have ,

$$\frac{Weight\ of\ metal}{eq.wt\ of\ metal} = \frac{Weight\ of\ H_2\ at\ NTP}{eq.wt\ of\ H_2}$$

$$\frac{0.175}{eq.wt\ of\ metal} = \frac{0.0135}{1.008}$$

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$$\text{Eq. wt of metal} = \frac{0.175 \times 1.008}{0.0135}$$

$$= \mathbf{13.067}$$

Hence,

$$\textbf{Equivalent weight of metal} = \mathbf{13.067\ gm}$$

2. a) Write down the postulates of Dalton's atomic theory.

➢ ***The postulates Dalton's atomic theory are :***

- ✓ Matters are composed of indivisible and extremely small particles called atoms.
- ✓ Atoms can neither be created nor be destroyed nor be transformed to the atoms of other elements.
- ✓ All the atoms of an element are alike but differ from the atoms of other elements.
- ✓ Atoms combine together in the ration of small whole numbers to give a compound atom called molecule.

b) 0.45 gm of metal when dissolved in dil. HCl gave $760°\ cc$ of H_2 at $27°$c and 640 mm Hg pressure. The specific heat at metal is 0.23. Calculate the exact atomic wt. of metal. (ag. at $27°c$ = 26.74 moHg.

➢ **Solution :**

Weight of metal (W) $= 0.45$g

Volume of H_2 (V) $= 760$ c.c. $= 760 \times 10^{-6} m^3$

Temperature (T) $= (27 + 273) = 300$k

Aquear tension (f) $= 26.74$ mm of Hg

Pressure $=$ 640 mm Hg pressure

$R = 8.314\ JK^{-1}\ m^{-1}\ n^{-1}$

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We have,

$$(P - F)V = nRT$$

$$(640 - 26.74)mm \times 760 \times 10^{-6} = n \times 8.314 \times 300$$

$$\text{Since, } 760mm = 1\text{ atm} = 1.01 \times 105\text{ NM} - 2$$

$$613.26 \times \frac{1.01 \times 10^5}{760} \times 760 \times 10^{-6} = n \times 8314 \times 300$$

$$n = 0.0248$$

Since,

$$n = \frac{\text{weight of hydrogen}}{\text{Molecular Weight of Hydrogen}}$$

$$\because \text{molecular Weight of Hydrogen} = 2\text{ g}$$

$$0.0248 = \frac{Weight\ of\ Hydrogen}{2}$$

$$\therefore \textbf{Weight of Hydrogen} = \mathbf{0.0496\ g}$$

Now,

$$\frac{\text{Weight of metal}}{\text{eq. wt of metal}} = \frac{\text{Weight of Hydrogen}}{\text{eq . wt of Hydrogen}}$$

$$\text{Eq. et of Hydrogen} = 1.008$$

$$\frac{0.45}{\text{eq. wt of metal}} = \frac{0.0496}{1.008}$$

$$Eq.wt\ of\ metal = \frac{0.45 \times 1.008}{0.0496}$$

$$= \mathbf{9.145}$$

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We have,

$$\text{Approx. Atomic Weight} = \frac{6.4}{\text{sp. heat}}$$

$$sp.heat = 0.23$$

$$\text{approx..Atomic Weight} = \frac{6.4}{0.23}$$

$$= \mathbf{27.826\ gram}$$

Now,

$$\text{Vatency} = \frac{\text{approx atomic Weight}}{\text{eq. wt of metal}}$$

$$= \frac{27.826}{9.145}$$

$$= 3.042$$

$$\approx \mathbf{3}$$

$$\text{Exact atomic Weight} = \text{Eq. wt of metal} \times \text{Valency}$$

$$= 9.145 \times 3$$

$$= \mathbf{27.435\ gm}$$

3. a) Define Avogadro's hypothesis. Show that the molecular weight of the compound is twice of it's vapour density.

- **Avogadro's hypothesis states that,** "equal volumes of all gases under the same conditions of temperature and pressure contain an equal number of molecules".

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➢ **We know,**

$$\text{Molecular weight} = \frac{\text{Weight of one molecule of the substance}}{\text{Weight ofone atom of hydrogen}}$$

$$\text{and, Vapour density} = \frac{\text{Weight of certain volume of a gas}}{\text{Weight of same volume of hydrogen gas}}$$

(At same temperature and pressure)

$$\text{V.D} = \frac{\text{Weight of (V) volume of the vapour of a substance}}{\text{Weight of (V) volume of hydrogen}}$$

(At same temperature and pressure)

Let 'V' volume of vapour of the substance contain 'n' molecules.

Therefore 'V' volume of hydrogen also contain 'n' molecules.

$$\textbf{V.D} = \frac{\textbf{Weight of n molecules of gas}}{\textbf{Weight of n molecules of hydrogen}}$$

$$= \frac{Weight\ of\ 1\ molecules\ of\ gas}{Weight\ of\ 1\ molecules\ of\ hydrogen}$$

$$= \frac{Weight\ of\ 1\ molecules\ of\ gas}{Weight\ of\ 2\ atom\ of\ hydrogen} \quad [\because hydrogen\ is\ diatomic]$$

$$= \frac{Weight\ of\ 1\ molecules\ of\ gas}{2 \times Weight\ of\ 1\ atom\ of\ hydrogen}$$

By definition of molecular weight; we have,

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$$V.D. = \frac{1}{2} \times molecular\ weight$$

$$\therefore\ Molecular\ weight\ =\ 2\ \times\ V.D.$$

Hence,

The molecular weight of the compound is twice of it's vapour density.

b) What is mole?

- ***Mole** is a unit used to measure the amount of a substance*. One mole of a substance contains the same number of particles as there are in 12 grams of carbon-12. This number is approximately $6.02\ \times\ 10^{23}$ particles and is known as Avogadro's number.

Calculate the no of mole in

i) 11.2 ltr of CO_2 at NTP.

➢

We have,

$$22.4\ L\ \ Contains\ \ 1\ mole\ of\ CO_2\ at\ NTP$$

$$1\ L\ \ Contains\ \ \frac{1}{22.4}\ mole\ of\ CO_2\ at\ NTP$$

By question,

$$11.2\ L\ contains\ \ \frac{11.2}{22.4}\ mole\ od\ CO_2\ at\ NTP$$

$$11.2\ L\ Contains\ \ 0.5\ \ mole\ \ of\ \ CO_2\ \ at\ \ NTP$$

$$No.of\ mole\ =\ 0.5$$

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Alternative Method :

We have, formula

$$No.of\ mole = \frac{\text{Volume of } CO_2 \text{ at NTP (in Ltr)}}{22.4\ \text{L}}$$

$$= \frac{11.2}{22.4}$$

$$\boldsymbol{No.of\ mole = 0.5}$$

ii) 20 $gm\ of\ CaCO_3$

➢

$$Weight\ of\ CaCO_3 = 20\ g$$

$$Molcular\ weight\ CaCO_3 = 40 + 12 + 16 \times 3$$

$$= 100g$$

Hence,

$$no.of\ mole = \frac{Weight\ of\ substance}{molcular\ Wieght}$$

$$= \frac{20}{100}$$

$$\boldsymbol{no.of\ mole = 0.2}$$

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4. a) Define acid and base in terms of Arrhenius concept with one examples of each.

- ***According to the Arrhenius concept,*** all substances which contain hydrogen and give H^+ ions when dissolved in water are called ***acids*** while those which contains hydroxyl groups and which when dissolved in water give OH^- ions are called ***bases***.

- ***Example of an acid***: *Hydrochloric acid* (HCl)

  When HCl is dissolved in water, it dissociates into H^+ and Cl^- ions, increasing the concentration of H^+ ions in the solution. The reaction can be written as:

$$\mathbf{HCl\,(aq) \longrightarrow H^+\,(aq) + Cl^-(aq)}$$

- ***Example of a base:*** *Sodium hydroxide* $(NaOH)$

  When $NaOH$ is dissolved in water, it dissociates into Na^+ and OH^- ions, increasing the concentration of OH^- ions in the solution. The reaction can be written as:

$$\mathbf{NaOH\,(aq) \rightarrow Na^+\,(aq) + OH^-\,(aq)}$$

Additional : If ask,

- **Limitations of Arrhenius concept :**

  - ✓ Hydrogen ion does not exist as free ion but combines with water molecule to form H_3O^+. This is not covered in this concept.
  - ✓ This concept is limited to only one solvent water.
  - ✓ It does not cover those compounds that act like acid (CO_2) and base (NH_3) though they do not contain H^+ and OH^- ion respectively.
  - ✓ The Arrhenius concept also does not explain the behavior of amphiprotic substances, which can act as both an acid and a base depending on the reaction, such as water(H_2O).

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b) 10^{-3} mole of NaOH is dissolved in 10 liters of water. What will be the pH of the solution?

➢ **Solution :**

$$\text{No. of mole NaOH (n)} = 10^{-3} \text{ mole}$$

$$\text{Volume of water (V)} = 10 \text{ L}$$

We have,

$$\text{Molarity(M)} = \frac{\text{no . of Mole}}{\text{Volume (in L)}}$$

$$= \frac{10^{-3}}{10}$$

$$= \mathbf{10^{-4}}\ (\boldsymbol{mole\ /\ L})$$

$$NaOH \xrightarrow{aa} Na^{+} + OH^{-}$$

$$10^{-4} \qquad\qquad 10^{-4}$$

Hence,

$$\text{Concentration of } [\,OH^{-}] = 10^{-4} \text{ mole / L}$$

$$P^{OH} = -\log[OH^{-}]$$

$$= -\log(10^{-4})$$

$$\mathbf{P^{OH} = 4}$$

Now,

$$\text{Since, } P^{H} + P^{OH} = 14$$

$$P^{H} = 14 - P^{OH}$$

$$= 14 - 4$$

$$\therefore\ \mathbf{P^{H} = 10}$$

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5. a) Write down the Rutherford atomic model in brief.

➢ *The Rutherford atomic model are below:-*

Rutherford' α – Scattering experiment →

When alpha partices are bombarded on thin gold foil, It is observed that.

- Most of α-partices (neary 99%) passes straight throught the points.
- Some are defected aways from the paths near the centre.
- Only a few are reflected back.

➢ *The diagram of the experiment is shown below :-*

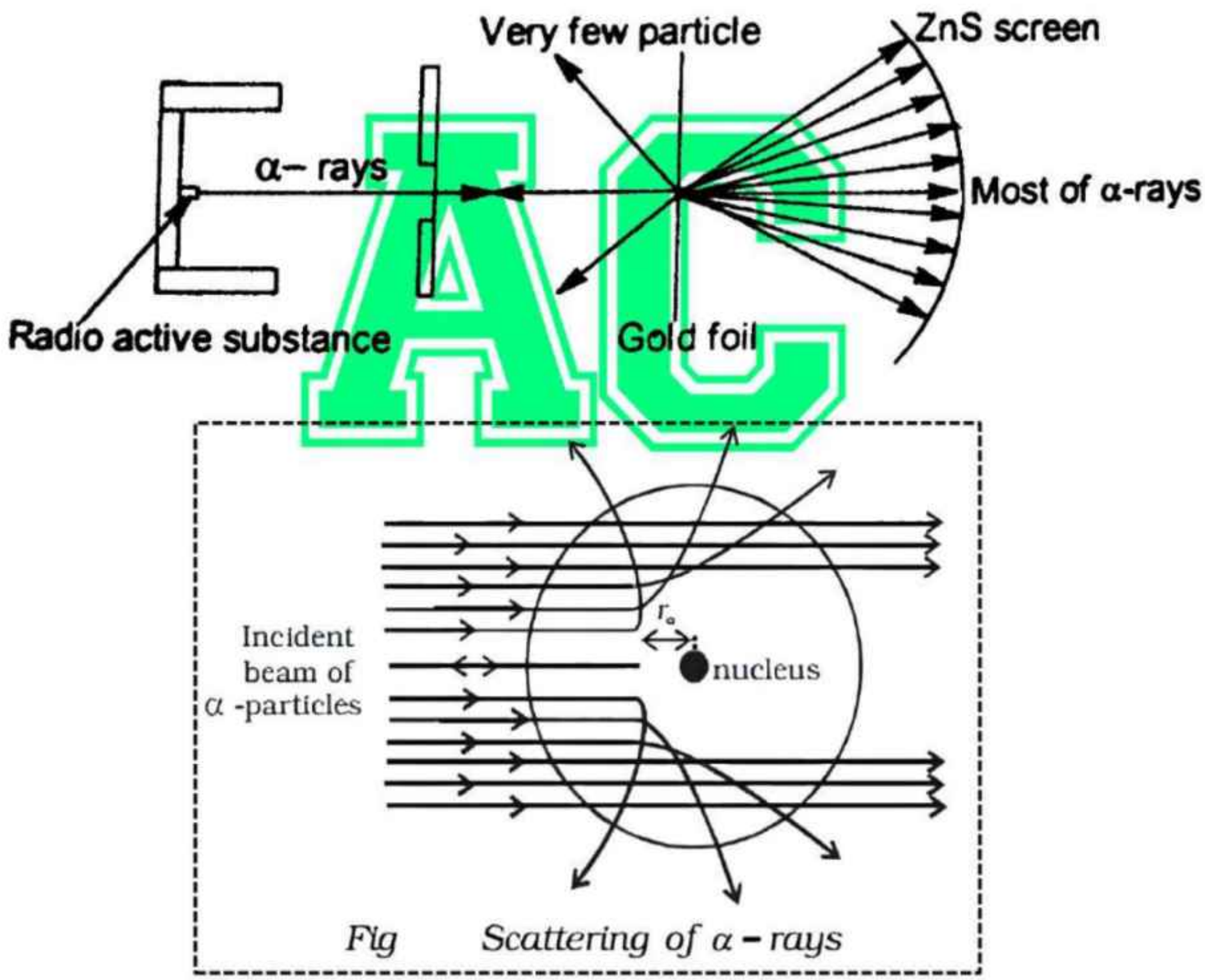

Fig Scattering of α – rays

On the basis of result of α Particles Scattering Rutherford's give a models of Rutherford's atomic model. It is also called *nuclear model of atom*.

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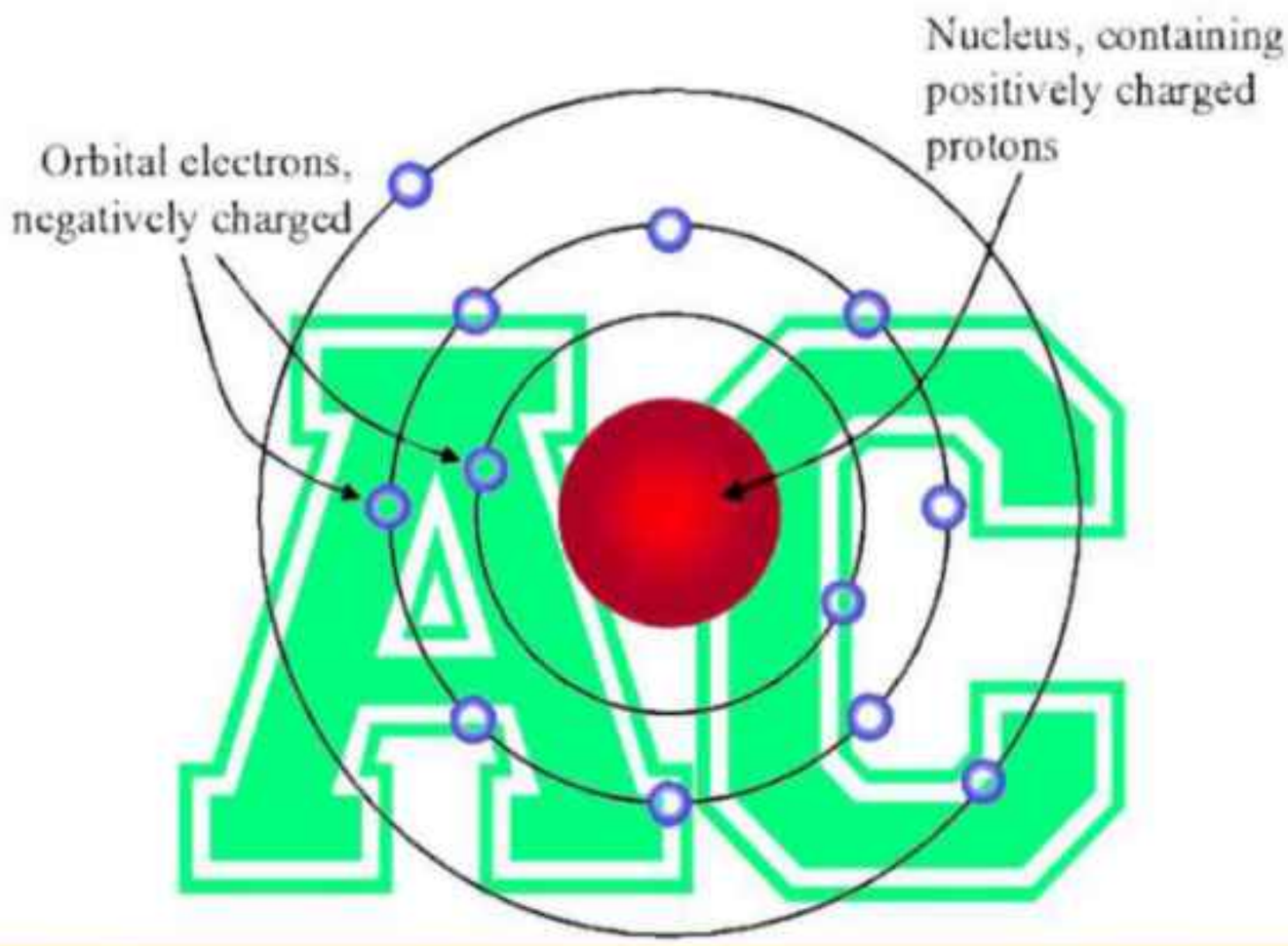
➢ **The important points of Rutherford Atomic Modals are given below :-**

- Atom is Spherical.
- Most part of the atom is empty.
- There is a very small heavy space in the center of atom where, almost entire mass of the atoms is concentrated or located. This Central parts of atom is called nucleus which is + vely charged .

  (This Space hash a of order of 10^{-11} to 10^{-13} cm as compare to radius of atom which of the order 10^{-13} cm).

- Electron moves around the nucleus in circular path.



b) Write any two differences between orbit and orbital's? Write the electronic configuration of cr in tem of S,p,d and f.

➢ ***Extra 4 point :***

Orbit	Orbital
The paths on which the electrons revolve are called orbits.	An orbital is a shape resulting in the combination of all probable orbits.
It is well-defined circular path followed by electrons around nucleus.	It is a region of space around the nucleus where the probability of finding an electron is maximum.
It is denoted by K, L, M, N,..... .	It is denoted by s, p, d and f

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All orbit are circular.	Orbital have various shapes.
Maximum number of electrons in an orbit is given by $2n^2$.	An orbital cannot hold more than 2 electrons.
The concept is developed form *Bohr's atomic model.*	The concept is developed form *Heisenberg's uncertainty principle*.

- ***Chromium***

Atomic number 24

Expected configuration of cr: $-1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^4$
Real Configuration of cr : $-1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1\ 3d^5$

This is because half – filled orbital are more stable.

6. a) Define oxidation and reduction in terms of oxidation number. State with example.

- *On the basis of oxidation number*, **Oxidation** may be defined as a reaction in which the oxidation number of an element in an atom, molecule or ion increases.
- **Reduction** may be defined as a reaction in which the oxidation number of an element in an atom, ion or molecule decreases.
- **Example:** The reaction between magnesium metal and oxygen to form magnesium oxide involves the oxidation of magnesium.

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

Oxidation

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The term reduction comes from the Latin stem meaning "to lead back." Anything that that leads back to magnesium metal therefore involves reduction.

The reaction between magnesium oxide and carbon at $2000C$ to form magnesium metal and carbon monoxide is an example of the reduction of magnesium oxide to magnesium metal.

$$MgO(s) + C(s) \longrightarrow Mg(s) + CO(g)$$

reduction

b) Balance the given equation by O.N. method.

$$\mathbf{Cu + HNO_3 \longrightarrow Cu(NO_3)_2 + NO_2 + H_2O}$$

➢

reduction

$$\overset{0}{\mathbf{Cu}} + \overset{+5}{\mathbf{HNO_3}} \longrightarrow \overset{+2}{\mathbf{Cu}}\mathbf{(NO_3)_2} + \overset{+4}{\mathbf{NO_2}} + \mathbf{H_2O}$$

Oxidation

Increase in oxidation number of Cu $= 2 - 1 = 2$

Decrease in oxidation number of N $= 5 - 4 = 1$

Since, there are two compounds containing nitrogen in product side, writing HNO_3 twice in reactant side.

$$Cu + HNO_3 + HNO_3 \longrightarrow Cu(NO_3)_2 + NO_2 + H_2O$$

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To balance, multiply Cu by 1 and N by 2 and balance these elements in product side.

$$Cu + 2HNO_3 + HNO_3 \longrightarrow Cu(NO_3)_2 + NO_2 + H_2O$$

Finally balance the remaining elements

$$Cu + 2HNO_3 + 2HNO_3 \longrightarrow Cu(NO_3)_2 + 2NO_2 + 2H_2O$$

Therefore, balanced equation is;

$$\mathbf{Cu + 4HNO_3 \longrightarrow Cu\,(NO_3)_2 + 2NO_2 + 2H_2O}$$

7 a) Define Alkalimetry and acidimetry. What indicator would you use during the titration between HCI and Na_2Co_3 and why?

- The determination of strength of acid by using standard alkali solution by titration in the presence of indicator is called ***alkalimetry***.

- The determination of strength of alkali solution by using standard acid solution in the presence of suitable indicator by titration is called ***acidimetry***.

- For the titration between hydrochloric acid and sodium Carbonate, the indicator used is methyl orange. Methyl Orange indicator (P^H range $3 - 4.4$) is used for titrations of a strong acid with a strong or weak base. HCl is strong acid and Na_2Co_3 is weak base. Therefore, methyl orange indicator is used.

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b) 200 ml of 0.8N H_2SO_4 is mixed with 250 ml of 0.6N NaOH. Is the resulting solution acid or basic? Calculate the normality of the resulting solution.

➢ **Solution:**

Given,

Acid	**Base**
$V_1 = 200ml$	$V_2 = 250\ ml$
$N_1 = 0.8\ V$	$N_2 = 0.6\ V$

200ml of 0.8N of H_2SO_4 = 160 ml of 1 N of H_2SO_4

250 ml of 0.6 N of NaOH = 150 ml of 1 N of NaOH

$V_{Total} = 450\ ml$ (V_3) vremain of Acid = $(160 - 150) = 10$ ml

$N_{Total} = ?$ $N_3 = 1\ N$

We have,

$$\mathbf{N_3\ V_3 = V_{Total} \times N_{Total}}$$

$$N_{Total} = \frac{10 \times 1}{450}$$

$$= 0.0222N$$

Normality of resulting Solution = 0.0222N

At 1N Solution

Volume of Acid = 160 ml

Volume of Base = 150 ml

$\boldsymbol{i.e.}\ V_{Acid} > V_{Base}$ $at\ 1N.$

Resulting Solution is Acidic.

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8. a) State and explain Faraday's 2nd law of electrolysis.

➢ ***Statement :***

If same quantity of electricity is passed through different electrolytes connected in series, then the amount of substances deposited or liberated at their respective electrodes are in the ratio of their equivalent weight.

➢ ***Explanation :***

Consider 3 cells containing H_2SO_4, $CuSO_4$ and $AgNO_3$, solutions are connected in series. If some quantity of electricity is passed through these cells, then amount of hydrogen, copper and silver deposited at the respective cathodes are in the ratio of their equivalent mass.

Hence,

$$\frac{\text{Mass of hydrogen}}{\text{Eq. mass of hydrogen}} = \frac{\text{Mass of copper}}{\text{Eq. mass of copper}} = \frac{\text{Mass of silver}}{\text{Eq. mass of silver}}$$

$$or\ ,\ \frac{\text{Mass of hydrogen}}{1.008} = \frac{\text{Mass of copper}}{31.75} = \frac{\text{Mass of silver}}{108}$$

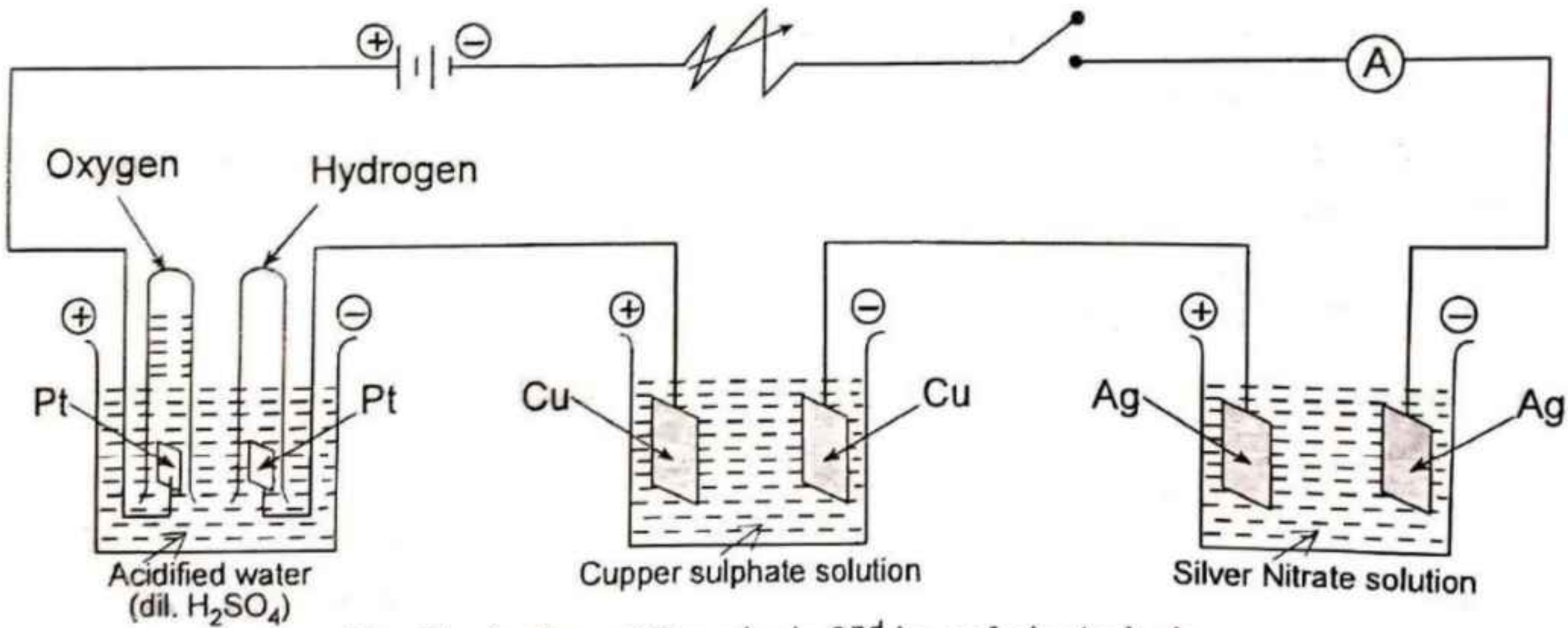

Fig: Illustration of Faraday's 2nd law of electrolysis

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b) 25 ml of $NaOH$ Solution required 20 ml of decinormal solution of complete neutralization. Find the strength of NaOH in terms of Normality, gram/litre and percentage strength.

➢ **Solution :**

$$\text{Eq wt of NaOH} = \frac{40}{1} = 40$$

For NaOH	**Fort Standard Solution**
$V_1 = 25$ ml	$V_2 = 20$ ml
$N_1 = ?$	$N_2 = \frac{N}{10}$ ($deci - normal\ solution$)

We have, $N_1 V_1 = N_2 V_2$

$$N_1 \times 25 = \frac{N}{10} \times 20$$

$$N_1 = 0.08\ N$$

Normality of NaOH = **0.08 N**

Now, $\text{Normality} = \frac{g/L}{\text{Eq. wt}}$

$$Gram\ Per\ Litre \left(\frac{g}{L}\right) = Normality \times Eq.wt\ of\ NaOH$$

$$= 0.08 \times 40$$

$$= 3.2\ gm/l$$

$$Gram\ Per\ Litre \left(\frac{g}{L}\right) = \%\left(\frac{W}{V}\right) \times 10$$

$$3.2 = \%\left(\frac{W}{V}\right) \times 10$$

$$\left(\frac{W}{V}\right)\% = \frac{3.2}{10}$$

$$\%\left(\frac{W}{V}\right) = 0.32$$

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$$\textbf{Percentage Strength} = 0.32\%$$

9. a) Define Modern periodic law. Write down the advantage of Modern periodic table.

- The **Modern Periodic Law** states that "the physical and chemical properties of elements are periodic functions of their atomic numbers." This means that as the atomic number of an element increases, its physical and chemical properties show a periodic pattern.
- ***The advantages of the Modern Periodic Table are as follows:***

✓ The modern periodic table is based on the electronic configuration of elements. This makes it easier to understand and predict the properties of elements.

✓ The periodic table provides a systematic arrangement of elements that helps in the identification of new elements and their properties.

✓ The modern periodic table helps in the classification of elements into different groups and periods based on their properties. This helps in the study of the relationship between elements and their properties.

✓ The periodic table helps in the prediction of the properties of new elements based on their position in the table.

b) Define the term electrovalency. Draw the Lewis structure of H_2SO_4.

- When an element combines with another element by losing or gaining electrons to form a compound, its valency is called ***electrovalency.***

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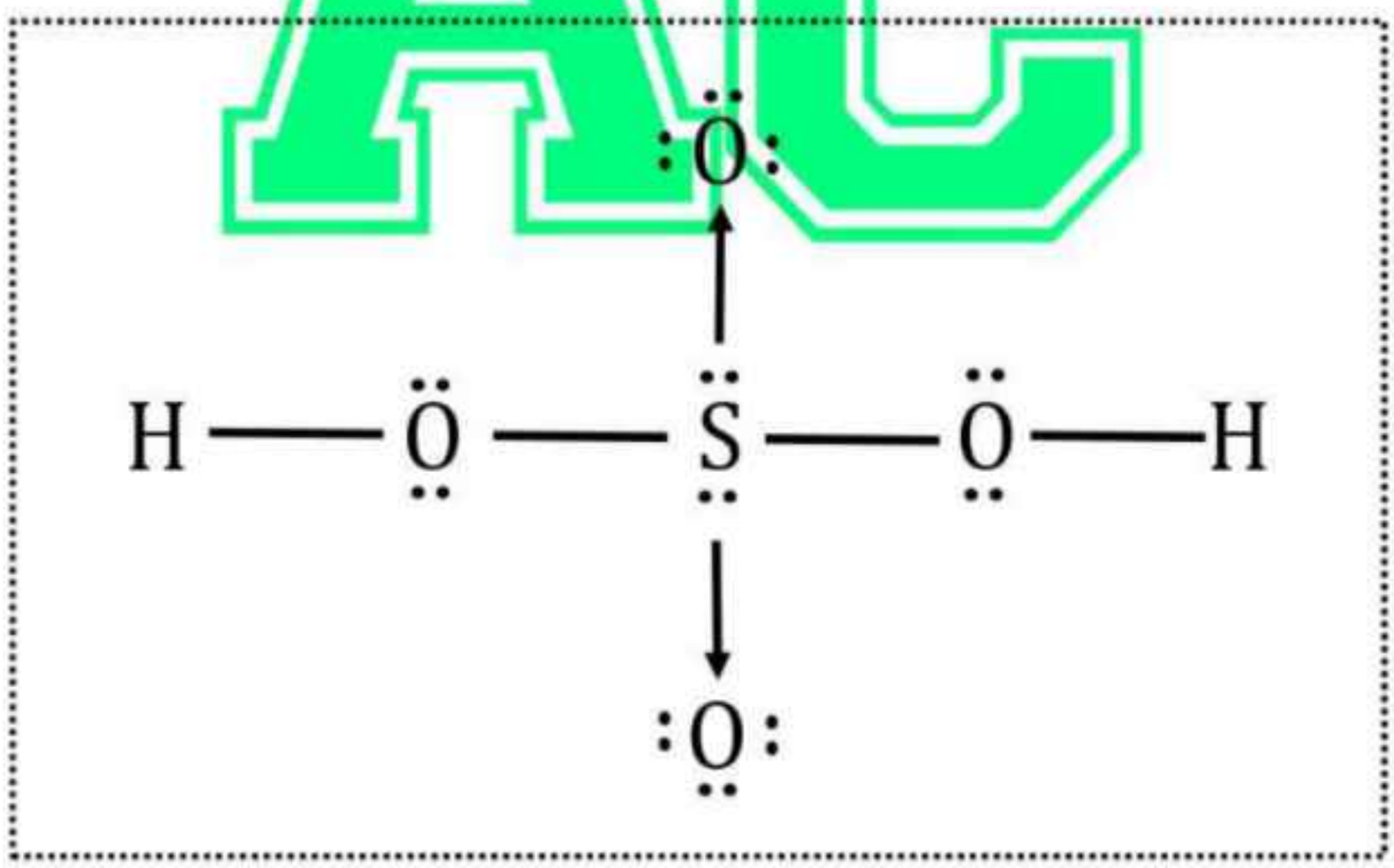
Example of Sodium atom:

- ✓ Consider a Sodium atom (**Na**) having atomic number 11. Thus, the number of electrons in a Sodium atom are **11**.
- ✓ The electronic configuration of Sodium is (**2, 8, 1**).
- ✓ In order to acquire eight electrons in the outermost shell i.e. to attain nearest noble gas configuration, Sodium atom loses 1 electron from the outermost shell.
- ✓ This leads to formation of Sodium ion having one unit of positive charge ($\mathbf{Na^+}$).
- ✓ Thus, the electrovalency of Sodium is **+1**.

➢ **The Lewis structure of H_2SO_4**



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10. Write short notes on:

a) Assumption of electronic theory of valency

➢ *The **assumptions of electronic theory of valency** are as follows:-*

- ✓ Only the valence electrons participate in chemical combination.
- ✓ Number of valence electrons determines the capacity of atoms to take part in chemical combination.
- ✓ Every element has tendency to acquire the nearest inert gas configuration which is considered as stable configuration.
- ✓ The combination of atoms takes place by transfer or mutual sharing or donating one or more valence electrons.
- ✓ The attractive forces which hold various constituents (atoms, ions) together in different chemical species are called chemical bond.

b) Electrochemical series

➢ The arrangement of various elements in order of increasing values of standard reduction potentials is called ***electrochemical series.*** The standard oxidation potential is equal to standard reduction potential with opposite sign.

{ ***A part of electrochemical series :***

$$Ag^+ + e = Ag \qquad \varepsilon^0 = +0.8\,v$$
$$2H^+ + 2e = H2 \qquad \varepsilon^0 = 0\,v$$

Positive sign of ε^0 indicates that the substance has greater tendency to reduce than hydrogen. }

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Uses :

- ✓ To predict whether a metal will liberate hydrogen gas from a hydracids or not. Any element with a negative value of ε^0 will be able to liberate hydrogen from dilute hydracids.
- ✓ To predict cell e.m.f. and feasibility of cell reaction.
- ✓ To predict the occurrence of a chemical reaction.
- ✓ To compare the relative reactivity of metals.

c) Aufbau principle

- **It states that**, "*Electrons occupy the orbital of minimum energy first and then they occupy the orbital of higher energy*."

In the ground state of an atom, the electron enters the orbital having the lowest energy first. On filling up the electrons in the increasing order of energy of the orbital, the system acquires stability. The orbital will be filled up by the electrons in the following sequence;

$$1s, 2s, 2p, 3s, 3p, 4s, 3d, 4p, 5s, 4d, 5p, 6s, 4f, 5d, 6p, \ldots\ldots\ldots$$

Some rules :

- ✓ The orbital having lower value of $(\mathbf{n}+\mathbf{1})$ has lower energy and hence is filled up first where **n** is principal quantum number and 1 is Azimuthal quantum number.
- ✓ When two orbital have the same $(\mathrm{n}+1)$ value, the orbital with lower value of n is lower in energy and hence is filled up first.

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d) Preventions from corrosion

➢ *The prevention of corrosion are given below :-*

- ✓ **Protective coatings** - Applying a layer of paint or powder coating can create a barrier between the metal and the environment.
- ✓ **Cathodic protection** - Connecting the metal to a sacrificial anode made of a more active metal can prevent corrosion.
- ✓ **Control the environment** - Reducing humidity, maintaining a certain temperature, or using a dehumidifier can reduce the risk of corrosion.
- ✓ **Alloying** - Adding a small amount of a more corrosion-resistant metal to the alloy can improve its corrosion resistance.
- ✓ **Galvanization** - Applying a layer of zinc can protect the metal from corrosion.
- ✓ **Proper maintenance** - Regular cleaning, inspection, and maintenance can prevent corrosion by removing any corrosive substances that may have accumulated on the surface.
- ✓ **Design considerations** - Proper design, including material selection, surface preparation, and proper drainage, can reduce the risk of corrosion.

e) Radicals

➢ An Atom or group of atoms carrying charge which acts as single unit in the chemical reaction is called ***radicals***.

Types of Radicals :

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- **Basic radical:** They have positive charge and are also called ***cations.*** They are formed by losing electrons. All metallic ions and ammonium ion are basic radicals.

  For example: Na^{+}, Cu^{2+}, NH^{4+}.

  Usually formed when metals lose electrons, eg. Na^{+}, Cu^{2+}.

- **Acid radical:** They have negative charge and are also called ***anions.*** They are formed by gaining electrons. Most of the non-metallic ions and groups of non-metallic atoms with negative charge are acid radicals.

  For example, Cl^{-}, SO_4^{2-}.

  Usually formed when nonmetals gain electrons, eg. Cl^{-}.

–The End –

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Engineering Chemistry I__(Engg. All) 1st Sem

(2078) Question Paper Solution.

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1.a) What do you mean by Eq. wt. of element? Prove that: Molecular wt. = 2 × Vapour density.

- It is the number of parts by weight of the substance that combines or displaces 1.008 parts by weight of hydrogen, 8 parts by weight of oxygen and 35.5 parts by weight of chloride.

➔ *2nd Part:* **Refer to the solution 2076 of Q. No 3 (a) on page 8.**

b) How is Dalton's atomic theory modified in the light of Modern Knowledge?

- John Dalton, in 1809 put forward the Dalton's atomic theory. The main postulates are:
  - ✓ Matters are composed of indivisible and extremely small particles called atoms.
  - ✓ Atoms can neither be created nor be destroyed nor be transformed to the atoms of other elements.
  - ✓ All the atoms of an element are alike but differ from the atoms of other elements.
  - ✓ Atoms combine together in the ration of small whole numbers to give a compound atom called molecule.

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A lot of modifications are needed now a days in this theory. Atom consists of subatomic particles like electron, proton etc. By nuclear reactions atom of one element can be changed into that of other. The ratio of number of atoms in sugar molecule $(C_{12}H_{22}O_{11})$ is not a simple whole number. Though this theory needs modifications, it has leaded the foundation of modern atomic chemistry.

2. a) State and explain Faraday's First law of electrolysis. Calculate the mass of copper deposited by electrolysis 2.5A current for 45 minutes through the solution of $CuSO_4$ (At. wt. of Copper $= 63.5$)

- **Faraday's first law**

The amount of a substance liberated or deposited at an electrode is directly proportional to the quantity of electricity passed.

Let, I = current in amperes

t = time in seconds; for which current is passed

W = the mass in grams of the substance deposited

From the first law; we have,

$$W \propto It$$

$$\therefore \mathbf{W = ZIt}$$

where, Z is E. C. E of the substance.

- **Solution:**

Given here,

Current (I) = 2.5A

Time (t) = 45 min = 45×60 = 2700 sec.

Atomic weight of copper = 63.5 gm

Deposited Mass (m) = ?

We know that, from faraday's first law,

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Mass deposited (m) = Zit

$$\mathbf{m = \frac{E}{F}\ It}$$

Or, $m = \frac{31.75}{96500} \times 2.5 \times 2700$ $\left(\because \text{In } CuSO_4 \text{ Solution; Equivalent weight of Cu} = \frac{63.5}{2} = 31.5\right)$

$\therefore m = 2.22gm$

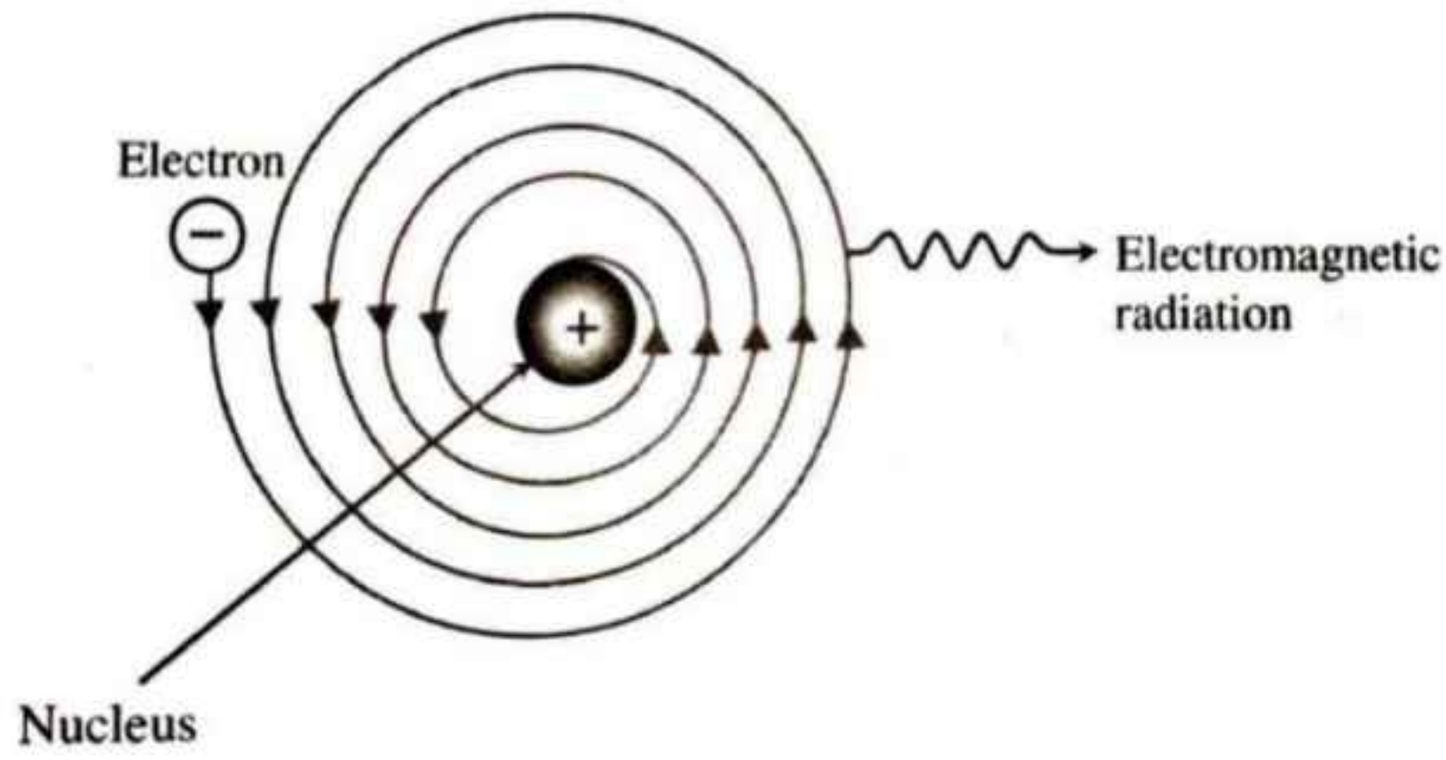
Thus,

$$\textbf{Mass of Cu deposited (m)} = \mathbf{2.22\ gm}$$

b) State drawback of Rutherford's atomic model. What are the basic postulates of Bohr's atomic Model?

➢ ***The drawback of Rutherford's atomic model are :-***

✓ The electron is revolving around the nucleus under the influence of attractive force and loses the energy in the form of electromagnetic radiations. Due to loss of energy, the speed of electron would slow down and its orbit becomes smaller and smaller and finally the electrons would fall into the nucleus. But electrons actually doesn't fall into the nucleus i.e. atoms are found to be stable.



✓ It doesn't explain atomic spectra of hydrogen.

✓ It doesn't explain how and where electrons are arranged.

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- **The postulates of Bohr's atomic Model are as follows.**

  - ✓ The electrons revolve around the nucleus in a fixed circular path, called an orbit. As long as an electron remains in a particular orbit, it neither loses nor gains energy. This creates atomic stability.

  - ✓ Electrons revolve only in those orbits in which angular momentum of an electron is an integral multiple of $\frac{h}{2\pi}$.

    $$i.e., \quad mvr = \frac{nh}{2\pi}$$

    Where, h is Planck's constant.

  - ✓ When an electron absorbs energy, its transition takes place from lower to higher orbits and absorption spectra is formed. When an electron jumps from higher orbits to lower, it radiates energy in the form of emission spectra.

    $$E_2 - E_1 = hf$$

    Where, f is frequency of radiation.

3. a) State Dulong's and Petit's law. $0.444\ gram$ of Metal when dissolved in dilute HCI gave $177\ ml$ of dry hydrogen at $10°c$ and $750\ mm\ Hg$ pressure, the specific heat of the metal is 0.107. Calculate exact atomic wt. of metal.

- **Dulong Petit's and Petit's Law :**

  According to Dulong and petit's law, the product of atomic weight and specific heat of a solid elements is approximately equal to 6.4.

  $$Atomics\ weight \times Specific\ heat = 6.4\ (approx.)$$

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$$or,\ Approximate\ atomics\ weight = \frac{6.4}{Specific\ heat}$$

$$Exact\ atomic\ weight = Equivalent\ weight \times valency$$

$$or,\ Valency = \frac{Approximate\ atomic\ weight}{Equivalent\ weight}$$

$$\boldsymbol{Atomic\ weight = Equivalent\ weight \times valency.}$$

- **Solution :**

$$Weight\ of\ metal\ (W) = 0.444\ gm$$
$$S.p.heat\ of\ Metal = 0.107$$

Now,

$V_1 = 177$ ml
$P_1 = 750$ mm
$T_1 = 10 + 273 = 283K$

$V_2 = ?$
$P_2 = 760$ mm
$T_2 = 273K$

We have ,

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$V_2 = \frac{T_2}{P_2} \times \left(\frac{P_1V_1}{T_1}\right)$$

$$V_2 = \frac{273}{760} \times \left(\frac{750 \times 177}{283}\right)$$

$$V_2 = 168.49\ ml$$

Density of Hydrogen (H_2) $\rho = 0.089 \times 10^{-3}$ g/ml

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$$\text{Weight of } H_2 = \rho . V_2 \qquad (\rho = \frac{M}{V})$$

$$= 0.09 \times 10^{-3} \times 138.49$$

$$= 0.0149 \text{ gram}$$

And,

Standara Value, $\text{E.q wt of } H_2 = 1.008$

$$\frac{\textbf{Weight of Metal}}{\textbf{Eq wt of Metal}} = \frac{\textbf{Weight of Hydrogen Produced}}{\textbf{Eq wt of Hydrogen } (H_2)}$$

$$\frac{0.444}{\text{Eq. wt of metal}} = \frac{0.0149}{1.008}$$

$$Eq.wt\ of\ metal = \frac{0.444 \times 1.008}{0.0149}$$

$$= \mathbf{30.03}$$

We have,

$$\text{Approx Atomic Weight} = \frac{6.4}{\text{sp . heat}} = \frac{6.4}{0.107} = \mathbf{59.81}$$

$$\text{Valency} = \frac{\text{Approx Atomic Weight}}{\text{Eq. wt of metal}} = \frac{59.81}{30.03} = \mathbf{1.99} \approx \mathbf{2}$$

Exact Atomic of Weight $= \text{Eq wt} \times \text{Valency of metal}$

$$= 30.03 \times 2$$

$$= 60.06 \text{ gram}$$

Hence, Exact atomic weight of metal = 60.06 gram.

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b) State Mendeleev's periodic law? Explain Mendeleev's periodic table in brief. Also mention it's anomalies.

- **Mendeleev's periodic law** states that " *the physical and chemical properties of elements are periodic functions of their atomic weights*". This means that the properties of elements are related to their atomic weights, and elements with similar properties occur at regular intervals. The periodic law is the basis for the arrangement of the elements in the modern periodic table.

- ***The (Features) of Mendeleev's periodic table In brief :-***

  - ✓ This table is based on the Mendeleev's periodic law which states, "The physical and chemical properties of all elements are periodic functions of their atomic mass".
  - ✓ The elements are arranged in nine vertical columns known as groups. The ninth one is called zero group.
  - ✓ There are seven horizontal rows known as periods. Six periods are complete whereas seventh one is incomplete.
  - ✓ All the groups except zero and VIII are further divided into subgroups A and B.
  - ✓ There are some blank spaces for undiscovered elements.

- **The anomalies of Mendeleev's periodic table are :-**

  - ✓ Position of hydrogen in the table is controversial.
  - ✓ Metals and non-metals are not separately placed.
  - ✓ Elements with higher atomic masses are placed before that of lower atomic masses.
  - ✓ Lanthanides and Actinides are not separated from the main body of the periodic table.

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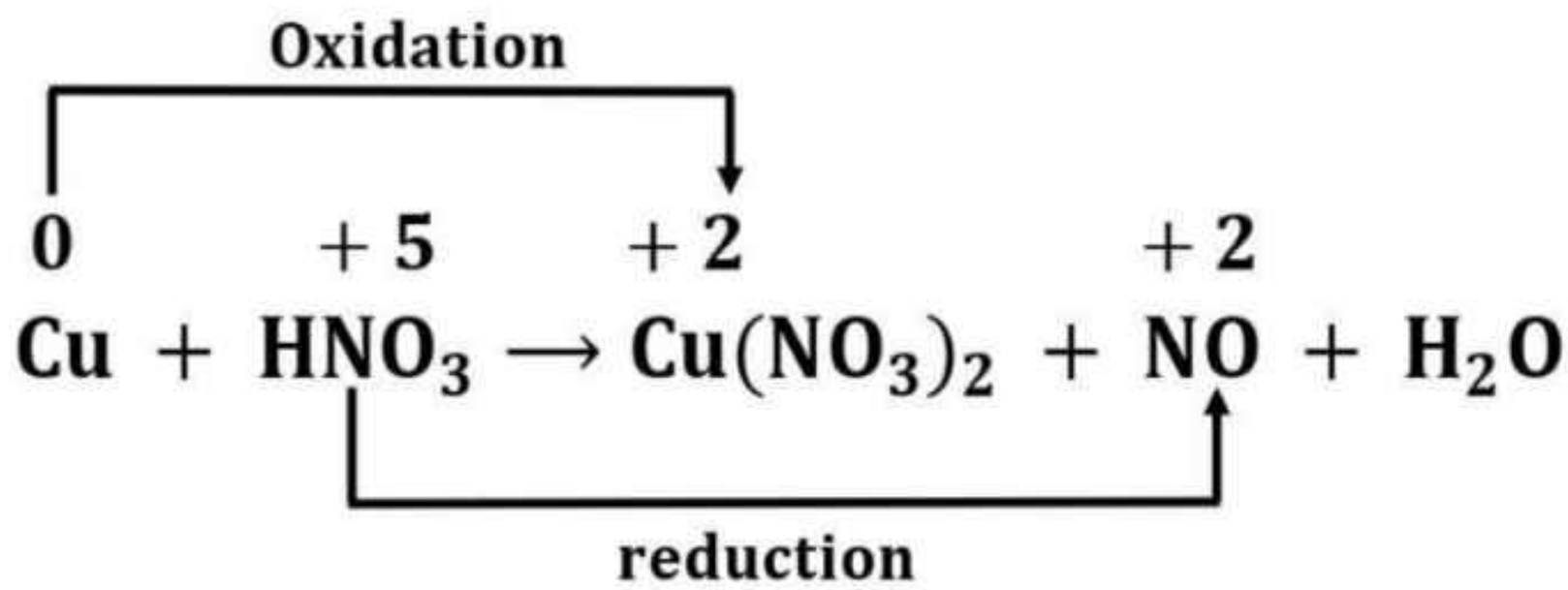
4. a) What is redox reaction? Balance the following chemical Equation by oxidation number method.

$$Cu + HNO_3 \longrightarrow Cu(NO_3)_2 + NO + H_2O$$

- The Reaction in which both oxidation and reduction goes side by side is called ***redox reaction.***

-



Increase in oxidation number of Cu = 2 – 0 = 2
Decrease in oxidation number of N = 5 – 2 = 3

Since, there are two products containing nitrogen in product side, writing HNO_3 twice in reactant side.

$$Cu + HNO_3 + HNO_3 \longrightarrow Cu(NO_3)_2 + NO + H_2O$$

To balance, multiply Cu by 3 and HNO_3 by 2 and balance these elements in product side.

$$3Cu + 2HNO_3 + HNO_3 \longrightarrow 3Cu(NO_3)_2 + 2NO + H_2O$$

Finally balance the remaining elements

$$3Cu + 2HNO_3 + 6HNO_3 \longrightarrow 3Cu(NO_3)_2 + 2NO + 4H_2O$$

Therefore, balanced equation is;

$$\mathbf{3Cu + 8HNO_3 \longrightarrow 3Cu(NO_3)_2 + 2NO + 4H_2O}$$

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b) What do you mean by acid and base according to Arrhenius concept? Also mention it's limitations.

→ Refer to the solution 2076 of Q. No 4 (a) on page 11.

5. a) What are the significance of given chemical Equation?

$$CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$$

Also, mention the limitations of chemical Equations.

- $CaCO_3 + 2HCl \longrightarrow CaCl_2 + H_2O + CO_2$

  $100gm \quad 73gm \quad 111gm \quad 18\,gm \quad 44gm$

They are as follows : –

1) Qualitative significance :

- ✓ Calcium carbonate and hydrochloric acid are reactants. Calcium chloride, water and carbon dioxide gas are products.
- ✓ Calcium carbonate reacts with hydrochloric acid to give calcium chloride, water and carbon dioxide gas.

2) Quantitative significance :

- ✓ 1 mole of $CaCO_3$ reacts with 2 moles of HCl to produce 1 mole of $CaCl_2$, 1 mole of H_2O and 1 mole of CO_2.
- ✓ 100 gm of $CaCO_3$, reacts with 73 gm of HCl to give 111 gm $CaCl_2$, 18 gm water and 44 gm CO_2.

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- **The limitations of Chemical Equations are :-**

  - ✓ Physical states of reactants and products are not indicated.
  - ✓ Speed of reaction and time taken for its completion is not given.
  - ✓ Concentration of the reactants and products is not indicated.
  - ✓ It does not tell whether the reaction is reversible or irreversible.
  - ✓ It does not tell whether the reaction is endothermic or exothermic.
  - ✓ It does not tell about the mechanism of the reaction.

b) How can you determine the Equivalent weight by indirect oxide formation method.

- **Equivalent weight by oxide formation method :**

In this a known weight of the metal is converted to its oxide by direct method or indirect method. Knowing the weight of metal and oxygen combined the equivalent mass of metal can be calculated as follows:

Let, Weight of metal $= W_1$ g

Weight of metal oxide $= W_2$ g

Weight of oxygen $= (W_2 - W_1)$ g

$(W_2 - W_1)$ g of oxygen combine with metal $= W_1$ g

8 g of **oxygen** combine with metal $= \dfrac{W_1}{W_2 - W_1} \times \mathbf{8}$

$\therefore$ Equivalent weight of metal $= \dfrac{W_1}{W_2 - W_1} \times 8$

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- **Indirect method :**

➢ This method is applied to metals like copper, lead etc. as they cannot be completely converted to their oxides by heating in excess of air or oxygen. In such case, the known weight of metal is taken in a crucible and concentrated nitric acid is added till whole of its dissolves. The metal nitrate thus formed is strongly heated to convert it to metal oxide. The heating is continued till the weight becomes constant. The calculations for equivalent weights are done as above.

For example :

$$Cu + 4HNO_3 \longrightarrow \underset{\text{Copper nitrate}}{Cu(NO_3)_2} + NO_2 + 2H_2O$$

$$2Cu(NO_3)_2 \longrightarrow \underset{\text{Copper oxide}}{2CuO} + 2NO_2 + O_2$$

Additional : If ask,

- **Direct method :**

➢ A known weight of metal like magnesium, zinc or calcium etc. is heated in a crucible in the presence of excess of air or oxygen until the weight of metal oxide formed becomes constant. At this stage, the whole weight of metal has change to its oxide.

For example:

$$2\,Mg + O_2 \longrightarrow \underset{\text{Magnesium oxide}}{2\,MgO}$$

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6. Write short notes on: (Any Five)

a) Radical

➢ **Refer to the solution 2076 of Q. No 10(e) on page 25**

b) Covalent bond

➢ The bond which is formed between two or more atoms of the same or different elements by equal sharing of electron between any two combining atom is known as *covalent bond*. It may be polar or non polar. It is denoted by dash line (−). **For Example** : Cl_2 molecule

Types of Covalent bond :

- ✓ ***Single covalent bond*:** It is formed by the sharing of one electron between the two combining atoms. Example: F_2, H_2 etc.
- ✓ ***Double covalent bond:*** It is formed by the sharing of two electrons between the two combining atoms. Example: O_2, CO_2 etc.
- ✓ ***Triple covalent bond:*** It is formed by the sharing of three electrons between two combining atoms. N_2 , C_2 etc.

c) Hund's rule

➢ Hund proposed a rule of filling of degenerate orbital with electrons which is known as ***Hund's rule*** for maximum multiplicity. This rule is stated as, "*Electrons in degenerate orbital in the ground state first fill singly, and then pairing-up starts*". When electrons enter a set of orbital of a given sub-shell, electron will pair up only when all the available orbital have had at least one electron each.

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d) Titration

- **Titration** is the word used to determine strength of a solution by reacting its known volume with solution of known volume and strengthIt is the experimental procedure of volumetric analysis.

Strength of unknown solution can be calculated with the help of the equation $V_1S_1 = V_2S_2$.

Types of Titration :

- ✓ Acid-alkali titration
- ✓ Redox titration
- ✓ Iodometry and iodimety
- ✓ Precipitation titration

In titration, indicators are used to indicate complete reaction between acid and base. Examples of indicators are litmus paper, phenolphthalein, methyl orange, etc.

e) Normality

- It is defined as the number of gram equivalents of solute present in one litre of the solution. *It is represented by N.*

i.e.,

$$\text{Normality (N)} = \frac{\text{Number of gm equivalents of solute}}{\text{Volume of Solution in litre}}$$

$$= \frac{\text{weight of solute in gm}}{\text{Equivalent weight of solute}} \times \frac{1}{\text{Volume of Solution in litre}}$$

$$or,\ \text{Normality} \times \text{Equivalent weight} = \text{Concentration in gm per litre}$$

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f) Primary standard substances

- Those substances whose standard solution can be prepared directly by dissolving known weight of the substance in definite volume of a solvent are known as ***primary standard substances.***

  For example;
  - ✓ Hydrated oxalic acid
  - ✓ Anhydrous sodium carbonate

- **The characteristics/requisites of a primary standard substance :**
  - ✓ It should be easily available in pure state in laboratory.
  - ✓ Its composition should not change during storage and in air during weighing.
  - ✓ It should be readily soluble in water and not decomposed by water.
  - ✓ It must possess high equivalent weight to minimise weighing errors.
  - ✓ It should not be hygroscopic or deliquescent.

–The End –

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(2079 New) Question Paper Solution.

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1) What do you mean by valency and variable valency? Explain symbol and its significance.

- ***Valency*** is the combining capacity of an element. The number of electrons donated or accepted by an atom of an element so as to have electronic configuration of nearest noble gas is called its valency.
- Having more than one valency of a single element is known as **variable valency**. An atom of such elements combines with different number of atoms of other elements to form two or more different compounds.
- **Symbol :** The abbreviations used in chemistry to represent the chemical elements, functional groups and chemical compounds in a chemical reactions are known as chemical symbols.
- **Significances :**
  - ✓ Symbols are considered significant as they represent the stoichiometric quantity of the element. They represent how many atoms of particular elements are being used or released in a chemical reaction.
  - ✓ The symbol represents the definite mass of a specific element in a chemical reaction.
  - ✓ Using symbols makes easy to remember the name and write a chemical equation accurately.

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2) What is the significance of given chemical equation:

$$CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$$

- $$\underset{100gm}{CaCO_3} + \underset{73gm}{2HCl} \longrightarrow \underset{111gm}{CaCl_2} + \underset{18gm}{H_2O} + \underset{44gm}{CO_2}\uparrow$$

They are as follows ;-

a) Qualitative significance :

- ✓ Calcium carbonate and hydrochloric acid are reactants. Calcium chloride, water and carbon dioxide gas are products.
- ✓ Calcium carbonate reacts with hydrochloric acid to give calcium chloride, water and carbon dioxide gas.

b) Quantitative significance :

- ✓ 1 mole of $CaCO_3$ reacts with 2 moles of HCl to produce 1 mole of $CaCl_2$ 1 mole of H_2O and 1 mole of CO_2.
- ✓ 100 gm of $CaCO_3$ reacts with 73 gm of HCl to give 111 gm $CaCl_2$ 18 gm water and 44 gm CO_2.

3) What do you mean by atomic mass unit? 0.5302 gram of metal yield 0.7052 gram of its chloride. The specific heat of the element is 0.059. Calculate the exact atomic weight of Metal.

- ***Atomic mass unit (amu)*** is a unit of measurement used to express the mass of atoms and molecules. It is defined as one-twelfth of the mass of a carbon-12 atom.

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➢ ***Solution :***

$$\text{Weight of metal} = 0.5302 \text{ gm}$$
$$\text{Weight of metal chloride} = 0.7052 \text{ gm}$$
$$\therefore \text{ Weight of chlorine} = 0.7052 - 0.5302 = 0.175 \text{ gm}$$

$$\therefore \text{ Eq. weight of metal} = \frac{\text{Weight of metal}}{\text{Weight of chlorine}} \times \text{ Eq. weight of chlorine}$$

$$= \frac{0.5302}{0.175} \times 35.5$$

$$= 107.6$$

$$\text{Also, atomic weight} \times \text{ specific heat} = 6.4 \text{ (approx)}$$

$$\text{Atomic weight} = \frac{\text{Weight}}{0.059} = 108.5 \text{ (approx)}$$

$$\text{Valency} = \frac{108.5}{107.6} = 1.008 \approx 1$$

$$\therefore \textbf{ Exact atomic weight} = \textbf{Eq. weight} \times \textbf{valency} = \mathbf{107.6 \times 1 = 107.6}$$

4) What do you mean by gram molecular weight? How can you prove that hydrogen, chlorine and nitrogen are diatomic gases according to Avogadro's hypothesis?

➢ **Gram molecular weight** is defined as the molecular weight expressed in gram which contains 6.023×1023 molecules of the substance.

$$\boldsymbol{i.e},\ \ Gram\ molecular\ Weight = 1\ mole = 6.023 \times 102\ molecules$$

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❖Hydrogen is diatomic

➢ Let us have the gaseous reaction

Hydrogen	+	Chlorine	→	Hydrogen chloride
1 vol.		1 vol.		2vol. (by expt)

Let, 1 vol. of hydrogen contains 'n' molecules of it

n molecules	n molecules	2n molecules
$\frac{1}{2}$ molecule	$\frac{1}{2}$ molecule	1 molecule

i.e., 1 molecule of hydrogen chloride has $\frac{1}{2}$ *molecule of hydrogen.*

By experiment, hydrogen chloride always gives only one kind of salt ($NaCl$) with $NaOH$ which shows that hydrogen chloride is monobasic. Its one molecule contains only one hydrogen atom. Therefore,

$$\frac{1}{2}\ molecule\ of\ hydrogen\ =\ 1\ atom$$

$$or,\ \ 1\ molecule\ of\ hydrogen\ =\ 2\ atoms$$

Hence, hydrogen is diatomic.

❖Chlorine is diatomic

➢ In the reaction of hydrogen and chlorine, by actual reaction, it is seen that:
1 volume of H_2 + 1 volume of Cl_2 = 2 volumes of hydrogen chloride

Let, 1 volume of gas contains n molecules, chlorine

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Hydrogen +	chlorine =	hydrogen chlorine
n molecules	n molecules	2n molecules
1 molecule	1 molecule	2 molecule
$\frac{1}{2}$ molecule	$\frac{1}{2}$ molecule	1 molecule

But one molecule of hydrogen chloride contains at least one atom of hydrogen and one atom of chlorine. These must come from $\frac{1}{2}$ molecule of hydrogen and $\frac{1}{2}$ molecule of chlorine.

Hence,

$$\frac{1}{2} \text{ molecule of chlorine} = 1 \text{ atom of chlorine}$$

$$1 \text{ molecule of chlorine} = 2 \text{ atoms of chlorine}$$

∴ **Hence, chlorine is diatomic.**

❖Nitrogen is diatomic

➢ We know,

Nitrogen	+	Hydrogen	=	Ammonia
1 vol.		3 vol.		2 vol.

Let, 1 vol. of nitrogen contains 'n' molecules then, from Avogadro's hypothesis,

n molecules	*3n molecules*	*2n molecules*
or, 1 molecule	*3 molecule*	*2 molecule*
or, $\frac{1}{2}$ *molecule*	$\frac{3}{2}$ *molecule*	*1 molecule*

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It shows that one molecule of ammonia contains $\frac{1}{2}$ molecule of nitrogen and $\frac{3}{2}$ molecule of hydrogen.

By experiment, it is found that nitrogen can be replaced from ammonia only once. It means ammonia contains only one atom of nitrogen.

$$\therefore\ 1 \text{ atom of nitrogen } = \frac{1}{2} \text{ molecule of nitrogen}$$

$$\therefore\ 1 \text{ atom of nitrogen } = 2 \text{ molecule of nitrogen}$$

Hence, nitrogen is diatomic molecule

5) What do you mean by equivalent weight of metal? Explain, the determination of equivalent weight of metal by indirect oxide formation method.

- 1st Part: **Refer to the solution 2078 of Q. No 1 (a) on page 27.**
- 2nd Part: **Refer to the solution 2078 of Q. No 5 (b) on page 36.**

6) 0.212 gram of metal where dissolved in dilute HCl evolves 218.2cc of hydrogen at 17°c and 745.5 mm Hg pressure over water. Find the equivalent weight of the metal (Aq. tension at 17°C =14.4 mm Hg).

- **Solution :** Weight of metal $= 0.212$ gm

Volume of hydrogen displaced (V) $= 218.2\text{cc} = 218.2 \times 10^{-4}\ \text{m}^3$

Temperature (T) $= 17 + 273 = 290\text{K}$

Pressure (P) $= 754.4\ \text{mm} = 1.002 \times 10^5\ \text{N m}^{-1}$

Aqueous Tension (f) $= 14.4\text{mm} = 1.9 \times 10^3 \times \text{Nm}^{-2}$

$\because$ ***For 760mm , Pressure*** $= 1.01 \times 10^5 Nm^{-2}$

$\therefore$ ***For 14.4mm , pressure*** $= \frac{14.4}{760} \times 1.01 \times 10^5 = 1.91 \times 10^3 Nm^{-2}$

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We know that,

$$(P - f)V = nRT$$

$$\text{or, } (P - f)V = \frac{m}{M}RT$$

$$or, m = \frac{(P - f)V \times M}{RT}$$

$$= \frac{(1.002 \times 10^5 - 1.9 \times 10^3) \times 218.2 \times 10^{-6} \times 2}{8.314 \times 290}$$

$$= 1.78 \times 10^{-2}\ gm$$

Now,

$$\frac{\text{Weight of metal}}{\text{Equivalent weight of metal}} = \frac{\text{Weight of hydrogen}}{\text{Equivalent weight of hydrogen}}$$

$$\text{Equivalent weight of metal} = \frac{\text{Wt. of metal} \times \text{Eq. wt. of hydrogen}}{\text{Wt. of hydrogen}}$$

$$= \frac{0.212 \times 1}{1.78 \times 10^{-2}}$$

$$= \mathbf{12}$$

$\therefore$ Equivalent weight of metal = 12gram

7) Explain Arrhenius concept of acid and base with its limitations.

→Refer to the solution 2076 of Q. No 4 (a) on page 11.

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Or) Calculate the $[H^+]$and$[OH^-]$ in 0.2M HCl solution.

➢ Given that: HCl dissociate Completely as strong acid

$$\underset{0.2M}{HCl} \longrightarrow \underset{0.2\ M}{H^+} + Cl^-$$

$so, [H^+] = \mathbf{0.2M}$ $, We\ know\ that;$

$$[H^+][OH^-] = 10^{-14}$$

$$or, [OH^-] = \frac{10^{-14}}{0.2} = 5 \times 10^{-14}\ M$$

$Therefore, the\ concentration\ of\ [OH^-] ions$

$$= 5 \times 10^{-14}\ M\ and\ [H^+]\ ion = 0.2\ M$$

8) What do you mean by molarity? Also mention the characteristics of primary standard substances.

➢ It is defined as the number of gram-moles of solute present in one litre of the solution. It is represented by M.

i.e.,

$$\text{Molarity (M)} = \frac{\text{Number of gram moles of solute}}{\text{Volume of Solution in litre}}$$

$$= \frac{\text{Weight of solute in gm}}{\text{Molecular weight of solute}} \times \frac{1}{\text{Volume of Solution in litre}}$$

$$or\ \text{Molarity} \times \text{Molecular weight} = \text{Concentration in gram per litre}$$

➔ 2nd Part: **Refer to the solution 2078 of Q. No 6 (f) on page 40.**

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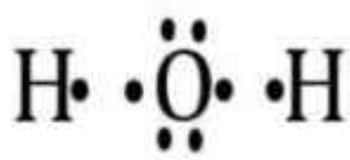
9) What are the basic assumptions of the electronic theory of valency? Write down the electron dot structure of

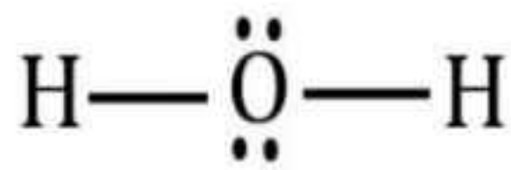
a) H_2O b) NH_3 c) C_2H_2

➢ 1st part: **Refer to the solution 2076 of Q. No 10 (a) on page 23.**

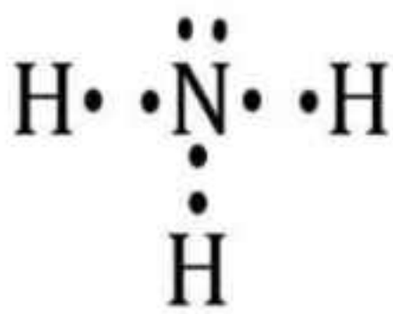
a) Dot structure of H_2O



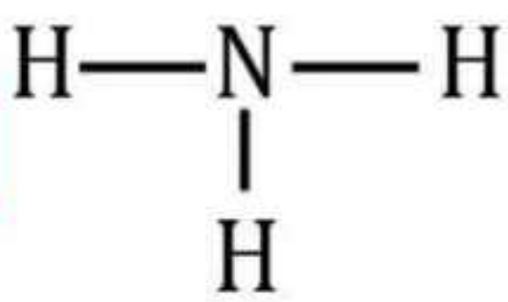
or,



b) Dot structure of NH_3



or,



c) Dot structure of C_2H_2

or,

10) What do you mean by electrolysis? Calculate the mass of copper deposited by electrolysis on passing 2.5A current for 45 minutes through the solution of $CuSO_4$. (Atomic weight of copper is 63.5).

➢ The process of chemical decomposition of an electrolyte in solution or molten state by the passage of electric current is called ***electrolysis.*** The principle of electrolysis is used in electroplating and electrolytic refining.

➢ 2nd Part: **Refer to the solution 2078 of Q. No 2 (a) on page 28.**

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OR) Define Faraday? Explain about Faraday's first law of electrolysis.

- The charge of 1 mole of electrons is called ***Faraday*** (F). It is calculated by multiplying the charge of one electron by the Avogadro constant.

1 Faraday's charge : Charge of 1 mole of electrons.

We know,

$$\text{charge of an electron} = 1.602 \times 10^{-19}$$

$$1 \text{ mole of electron} = 6.023 \times 10^{23} \text{ electrons}$$

Therefore,

$$\text{Charge of 1 mole electrons} = 6.023 \times 10^{23} \times 1.602 \times 10^{-19}$$

$$= 9.6488 \times 104$$

$$= 96488$$

$$\approx 96500 \text{ coulombs}$$

$\therefore$ **1 Faraday's charge = 96500 coulombs**

- 2nd Part: **Refer to the solution 2078 of Q. No 2 (a) on page 28.**

11) State Mendeleev's periodic law. Explain the periodic table of Mendeleev's. What are it's advantages?

- **Refer to the solution 2078 of Q. No 3(b) on page 33.**

12) What do you mean by redox reaction? Explain how the oxidation and reduction go side by side.

- The reaction in which both oxidation and reduction goes side by side is called ***redox reaction.***

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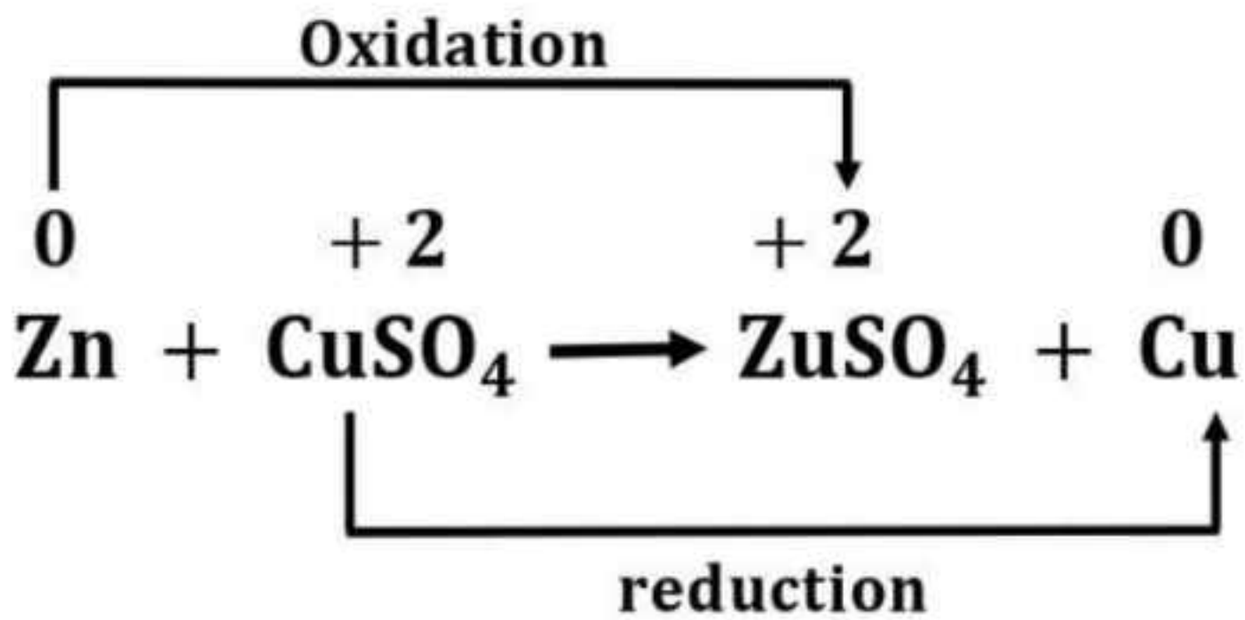
➢ **Consider a redox reaction :**



In this reaction, zinc is oxidized by CuSO, and there is reduction of copper by zinc.

Oxidation half reaction: $Zn \longrightarrow Zn^{++} + 2e$
Reduction half reaction: $Cu^{++} + 2e \longrightarrow Cu$

The two electrons lost by zinc during oxidation are accepted by Cu^{++} ion and Cu^{++} is reduced to Cu. Hence, in every reaction, electrons lost by one species are accepted by another species and oxidation and reduction goes side by side.

13) Balance the redox reaction by oxidation number method:

$$Cu + HNO_3 \longrightarrow Cu(NO_3)_2 + NO + H_2O$$

➢ **Refer to the solution 2078 of Q. No 4(a) on page 34.**

14. What do you mean by quantum numbers; explain.

➢ The set of four numbers from which we can get complete information of an electron in an atom is called ***quantum numbers***.

The four quantum numbers are;

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a) Principal quantum number (n) :

- It represents the main shell (K, L, M, ...) and tells about the size and energy of an electron.

b) Azimuthal quantum number (l) :

- It represents number of sub shells present in a main shell and tells about the shape of a sub shell.

c) Magnetic quantum number (m) :

- It represents number of orbital in a sub shell and tells about the orientation of the orbital.

d) Spin quantum number (s) :

- It tells the direction of spin of electron i.e., clockwise $+\frac{1}{2}$ or ↑ or anticlockwise $-\frac{1}{2}$ or ↓.

15) Explain the postulates of Bohr's atomic model.

- **Refer to the solution 2078 of Q. No 2(b) on page 30.**

–The End –

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(2079 Old) Question Paper Solution.

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1. a) Define chemical equation. What are it's significance according to given equation?

$$CaCO_3 + 2HCl \longrightarrow CaCl_2 + H_2O + CO_2$$

- A symbolic representation of the species involved in the chemical reaction is defined as ***chemical equation***.

$$2H_2 + O_2 \longrightarrow 2H_2O$$

- 2nd Part: **Refer to the solution 2078 of Q. No 5(a) on page 35.**

b) What do you mean by radicals? Explain the Daltons atomic theory.

- An Atom or group of atoms carrying charge which acts as single unit in the chemical reaction is called ***radicals***.

- 2nd Part: **Refer to the solution 2078 of Q. No 1(b) on page 27.**

2. a) State Dulong's and petit's law. How can you determine the atomic weight by this method?

- **Refer to the solution 2078 of Q. No 3(a) on page 30.**

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b) What is Avogadro's hypothesis. Also establish, molecular weight $= 2 \times V.D.$

➢ **Refer to the solution 2076 of Q. No 3(a) on page 7.**

3. a) Valency of metal is 3 and it's oxide Contains 31.6% of oxygen. Calculate the atomic weight of metal.

➢ **Solution :**

Valency of metal (V) $= 3$
At wt of metal $= ?$

Oxide Contain 31.6% of oxygen

Let wt of oxide $= 100gm$
Wt of oxygen $= 31.6\ gm$
Wt of metal $= (100 - 31.6) = 68.4\ gm$

We have,

$$\frac{\text{Wt of metal}}{\text{E.q wt of metal}} = \frac{\text{Weight of oxygen}}{\text{E.q wt of oxygen}}$$

$$\text{E.q wt of metal} = \frac{\text{Wt of metal}}{\text{Weight of oxygen}} \times \text{E.q wt of oxygen}$$

$$= \frac{68.4}{31.6} \times 8$$

$$= 17.316$$

Atomic weight of metal = Valency × Eq wt of metal

$$= 3 \times 17.316$$

$$= \mathbf{51.949\ gm}$$

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b) How can you determine the Equivalent weight by indirect oxide formation method.

- **Refer to the solution 2078 of Q. No 5 (b) on page 36.**

4. a) State and explain Bronsted and Lawry concept of acid and base. Why water is called amphoteric substance?

- ***According to this concept***, a substance which furnishes proton is called acid (proton donor) and a substance which accepts proton is called base (proton acceptors).

Consider a reaction,

$$\underset{\text{acid}}{HCl} + \underset{\text{base}}{H_2O} \rightleftharpoons \underset{\text{acid}}{H_3O^+} + \underset{\text{base}}{Cl^-}$$

In this reaction, HCI donates a proton (H^+) so it is acid and proton acceptor H_2O is base. Also, Cl^- acts as base and H_3O^+ as acid. The pair HCI and Cl^- is known as conjugate pair as they differ only by H^+ .

Strong acid has weak conjugate base and weak acid has strong conjugate base.

- Water is called amphoteric substance because :

Water (H_2O) acts as both Bronsted acid and base i.e

i) Water donates proton so it is Bronsted acid.

$$\underset{\text{base}}{NH_3} + \underset{\text{acid}}{H_2O} \rightleftharpoons \underset{\text{acid}}{NH_4^+} + \underset{\text{base}}{OH^-}$$

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ii) **Water accepts proton so it is Bronsted base.**

$$\underset{\text{acid}}{HCl} + \underset{\text{base}}{H_2O} \rightleftharpoons \underset{\text{acid}}{H_3O^+} + \underset{\text{base}}{Cl^-}$$

b) State Modern periodic law. Describe the anomalies and advantages of Mendeleev's periodic table.

- 1st part : **Refer to the solution 2076 of Q. No 9 (a) on page 21.**
- 2nd Part: **Refer to the solution 2078 of Q. No 3(b) on page 33.**

5. a) What are the basic assumptions of electronics theory of valency? Explain covalent bond with example.

- 1st part : **Refer to the solution 2076 of Q. No 10 (a) on page 23.**
- 2nd Part: **Refer to the solution 2078 of Q. No 6 (b) on page 38.**

b) Explain the main postulates of Bohr's atomic model.

- **Refer to the solution 2078 of Q. No 2(a) on page 30.**

6. a) What do you mean by electrolytes? Explain the Faradays First laws of electrolysis.

- An electrolyte is that substance which conducts electricity in aqueous or in fused state and simultaneously undergoes decomposition. For example; KOH, HCl, etc. conducts electricity.

- 2nd Part: **Refer to the solution 2078 of Q. No 2 (a) on page 28.**

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b) What do you mean by oxidation and reduction according to electronic concept? Balance the equation by oxidation number method:-

$$Zn + HNO_3 \longrightarrow Zn(NO_3)_2 + NO + H_2O$$

- ***Oxidation*** is defined as the chemical process which involves the loss of electrons and increase in oxidation number.

For Example;

$$Fe \longrightarrow Fe^{++} + 2e^-$$
$$2Br^- \longrightarrow Br_2 + 2e^-$$

Oxidation is a de-electronation process.

- **Reduction** is defined as the chemical process which involves the gain of electrons and decrease in oxidation number.

For Example;

$$Fe^{++} + 2e^- \rightarrow +Fe$$
$$Br_2 + 2e^- \rightarrow 2Br^-$$

Reduction is an electronation process.

- **Oxidation**

$$\overset{0}{Zn} + \overset{+5}{HNO_3} \longrightarrow \overset{+2}{Zn(NO_3)_2} + \overset{+2}{NO} + H_2O$$

reduction

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Increase in oxidation number of Zu $= 2 - 0 = 2$

Decrease in oxidation number of N $= 5 - 2 = 3$

Since, there are two products containing nitrogen in product side, writing HNO_3 twice in reactant side.

$$Zn + HNO_3 + HNO_3 \longrightarrow Zn(NO_3)_2 + NO + H_2O$$

To balance, multiply Zn by 3 and HNO_3 by 2 and balance these elements in product side.

$$3Zn + 2HNO_3 + HNO_3 \longrightarrow 3Zn(NO_3)_2 + 2NO + H_2O$$

Finally balance the remaining elements

$$3Zn + 2HNO_3 + 6HNO_3 \longrightarrow 3Zn(NO_3)_2 + 2NO + 4H_2O$$

Therefore, balanced equation is;

$$\mathbf{3Zn + 8HNO_3 \longrightarrow 3Zn(NO_3)_2 + 2NO + 4H_2O}$$

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1. a) State Avogadro's hypothesis. Derive a relation molecular Weight = 2 × Vapour Density.

➢ **Refer to the solution 2076 of Q. No 3(a) on page 7.**

b) Define equivalent weight of an element. What is meant by gram equivalent? 0.54gm of a metal gives 0.90gm of its oxide. Calculate the eg. wt. of the metal.

➢ 1st Part: **Refer to the solution 2078 of Q. No 1 (a) on page 27.**

➢ Equivalent weight of any substance expressed in gram is called **gram equivalent.**

$$\text{Number of gram equivalent} = \frac{\text{Weight of substance in gm}}{\text{Equivalent weight}}$$

Since, equivalent weight of $H_2SO_4 = 49$

$\therefore$ 49 gm of H_2SO_4 = 1 gram equivalent of H_2SO_4

➢ **Solution :**

Given that

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Wt. of metal $= 0.54$ gm

Wt. of Oxide $= 0.90$ gm

$\therefore$ Wt of oxygen = wt. of oxide − wt. of metal

Wt of oxygen $= 0.90 - 0.54$

Wt of oxygen $= 0.36$ gm

We have, Eq. wt of oxygen = 8 gm

$$\frac{\textbf{Wt of Metal}}{\textbf{Eq. wt of Metal}} = \frac{\textbf{Wt of oxygen}}{\textbf{Eq. wt of oxygen}}$$

$$\text{Eq. wt of metal} = \frac{\text{Wt of metal}}{\text{wt of oxygen}} \times \text{Eq. wt of oxygen}$$

$$\text{Eq. wt of metal} = \frac{0.54}{0.36} \times 8$$

$\therefore$ **Eq. wt of metal = 12 gm.**

2. a) Write down the significance of following chemical equation.

$$\mathbf{Na_2CO_3 + 2HCl \rightarrow 2NaCl + H_2O + CO_2}$$

- $\mathbf{Na_2CO_3 + 2HCl \longrightarrow 2NaCl + H_2O + CO_2 \uparrow}$

  106 gm 73 gm 117 gm 18 gm 44gm

They are as follows : –

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a) Qualitative information

- ✓ Sodium carbonate when reacts with hydrochloric acid produce sodium chloride, water and carbon dioxide.

b) Quantitative information

- ✓ One molecule of sodium carbonate reacts with two molecules of hydrochloric acid to produce two molecules of sodium chloride, one molecule of water and one molecule of carbon dioxide gas.
- ✓ 106 parts by weight of sodium carbonate reacts with 73 parts by weight of hydrochloric acid to produce 117 parts by weight of sodium chloride, 18 parts by weight of water and 44 parts by weight of carbon dioxide gas.
- ✓ One mole of sodium carbonate reacts with hydrochloric acid to produce 1 mole of carbon dioxide gas *ie*., 22.4 litre of carbon dioxide at N.T.P.

AC

b) What are the limitations of chemical equation?

➢ **Refer to the solution 2078 of Q. No 5 (a) on page 36.**

c) Discuss the anomalies of Mendeleev's periodic table.

➢ **Refer to the solution 2078 of Q. No 3(b) on page 33.**

3. a) Explain the Rutherford's atomic model with X-ray scattering experiment, with labelled diagram.

➢ **Refer to the solution 2076 of Q. No 5 (a) on page 13.**

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b) State and explain Faraday's 2nd law of electrolysis.

➢ **Refer to the solution 2076 of Q. No 8 (a) on page 19.**

4. a) Explain the oxidation and reduction according to classical concept with example. Balance the following equation of oxidation number method:-

$$Zn + HNO_3 \longrightarrow Zn(NO_3)_2 + NO + H_2O$$

➢ *According to the classical concept,* **Oxidation** is defined as the process which involves ***addition of oxygen or removal of hydrogen***.

For example:

$S + O_2 \longrightarrow SO_2$ (addition of oxygen)

$C + O_2 \longrightarrow CO_2$ (addition of oxygen)

$H_2S + Br_2 \longrightarrow 2HBr + S$ (removal of hydrogen)

➢ *According to the classical concept,* **Reduction** is defined as the process which involves ***addition of hydrogen or removal of oxygen***.

For example:

$H_2 + Cl_2 \longrightarrow 2HCl$ (removal of hydrogen)

$H_2 + Br_2 \longrightarrow 2HBr$ (removal of hydrogen)

$ZnO + C \longrightarrow Zn + CO$ (addition of oxygen)

➢ 2nd Part: **Refer to the solution 2079 (old) of Q. No 6 (b) on page 57.**

b) State and explain Arrhenius concept of acid and base with its limitations.

➔ **Refer to the solution 2076 of Q. No 4 (a) on page 11.**

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5. a) Calculate the amount of Na_2CO_3 required to prepare it's decinormal solution in 650ml solution. Also mention the characteristics of primary standard substances.

➢ The molar mass of Na_2CO_3 (sodium carbonate) is:

$$Na = 23\ g/mol, C = 12\ g/mol, O = 16\ g/mol$$

$$\begin{aligned} \text{Molar mass of } Na_2CO_3 &= (2 \times Na) + C + (3 \times O) \\ &= (2 \times 23) + 12 + (3 \times 16) \\ &= 46 + 12 + 48 \\ &= \mathbf{106}\boldsymbol{gm}. \end{aligned}$$

$$\text{Eq. wt of } Na_2CO_3 = \frac{\text{Mol. wt}}{\text{No of Ions in } CO_3^{--}} = \frac{106}{2} = \mathbf{53gm}$$

$\because Na_2CO_3 \rightarrow 2Na^+ + CO_3^{--}$

$$\text{Normality(N)} = \frac{N}{10} = 0.1N(\text{Deci} - \text{Normal}), \text{Volume} = 650\ \text{ml}$$

$$\text{Normality} = \frac{\text{Weight of } Na_2CO_3}{\text{volume(in ml). Eq. wt of} Na_2CO_3} \times 1000$$

$$\text{Weight of } Na_2CO_3 = \frac{\text{Normality} \times \text{Volume(ml)} \times \text{Eq. wt}}{1000}$$

$$\text{Weight of } Na_2CO_3 = \frac{0.1 \times 650 \times 53}{1000}$$

$$\therefore \textbf{Weight of } Na_2CO_3 = 3.445\ \textbf{gm}.$$

Hence, the amount of Na_2CO_3 required to prepare it's Decinormal solution in 650ml solution is 3.445 gm.

➔ 2nd Part: **Refer to the solution 2078 of Q. No 6 (f) on page 40.**

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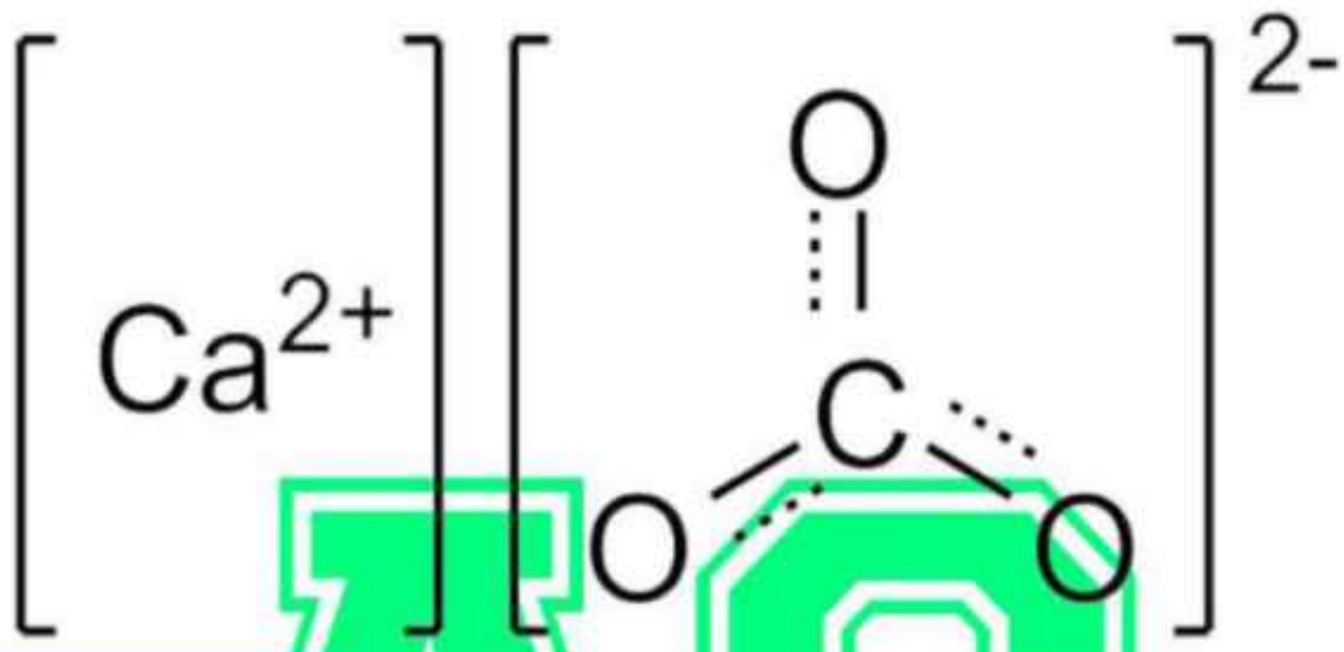
b) What do you mean by covalent bond? Explain with examples. Write down Lewis structure of H_2SO_4, $CaCO_3$.

➔ 1st Part: **Refer to the solution 2078 of Q. No 6 (b) on page 38.**

➔ 2nd Part: **Refer to the solution 2076 of Q. No 9 (b) on page 22.**

➔ **The Lewis structure of $CaCO_3$**



6. Write short notes on:

a) Corrosion

➢ The process of slowly eating away of the metal due to attack of atmospheric gases on the surface of the metal resulting in the formation of compounds such as oxides, sulphides, carbonates, sulphates, etc is called ***corrosion.*** The most common example of corrosion is rusting of iron. Rust is hydrated ferric oxide, $Fe_2O_3 \cdot H_2O$.

The factors which promote corrosion are :

- ✓ Presence of impurities enhances corrosion.
- ✓ More reactive metals are readily corroded.
- ✓ Presence of air and moisture accelerate corrosion.
- ✓ Corrosion takes place rapidly at bends, cuts and scratches in metals.
- ✓ Presence of electrolytes increases the rate of corrosion.

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b) Electrochemical series

➢ **Refer to the solution 2076 of Q. No 10 (b) on page 23.**

c) Buffer Solution

➢ If a solution contains a weak acid and its conjugate base, or a weak base and its conjugate acid, then the solution can resist change in the P^H and is called ***buffer solution***.

For example: Blood is a buffer with $P^H = 7.4$

Depending upon the P^H values, ***buffer solutions are divided into two classes:***

- If the P^H of the buffer solution is less than 7 is called ***acidic buffer.***

  For example: Weak acid and its conjugate base,

  $$\mathbf{CH_3COOH + CH_3COONa}$$

- If the P^H of the buffer solution is more than 7 is called **basic buffer.**

  For example: Weak base and its conjugate acid,

  $$\mathbf{NH_4OH + NH_4Cl}$$

d) Postulates of Dalton's atomic theory

➢ **Refer to the solution 2078 of Q. No 1 (b) on page 27.**

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e) Redox reaction

➢ **Refer to the solution 2079 (New) of Q. No 12 on page 50.**

f) Hund's rule

➢ **Refer to the solution 2078 of Q. No 6 (c) on page 38.**

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1) What do you mean by radicals? Explain its types with examples. Also, explain significance of formula.

➢ **1st Part: Refer to the solution 2076 of Q. No 10(e) on page 25**

➢ **Significance of Formula :**

❖ **Qualitatively :**

✓ It tells us name of substance and what elements the substance contains.

❖ **Quantitatively :**

- It signifies ;

✓ 1 mole of substance equal to 6.023×10^{23} number of Molecules.

✓ Molecular mass of substance.

✓ Number of each kind of atoms.

Example : Molecular formula of copper sulphate crystal is $CuSO_4$, $5H_2O$. It contains on copper atom, one sulphur atom, four oxygen atoms and five water molecules.

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2) What are the essentials and limitations of chemical equations?

➢ ***The essentials of Chemical Equations are : -***

✓ By simple contact

$$2P + 3I_2 \longrightarrow 2PI_3$$

✓ By contact through solution

$$AgNO_3\ (aq.) + NaCl\ (aq.) \longrightarrow AgCl\ (s) + NaNO_3\ (aq.)$$

✓ By the application of heat

$$Cu + 2H_2SO_4 \xrightarrow{\Delta} CuSO_4 + 2H_2O + SO_2$$

✓ By the application of pressure and light

$$CH_4 + Cl_2 \xrightarrow{hv} CH_3Cl + HCl$$

✓ By the application of electricity

$$2H_2O \xrightarrow{Current} 2H_2 \uparrow + O_2 \uparrow$$

➢ 2nd Part : **Refer to the solution 2078 of Q. No 5 (a) on page 36.**

3) Define atomic weight. State Dulong's and Petit's law and its methods to determine atomic weight.

➢ The atomic weight of an element is defined as the average relative weight of an atom of the element compared to the weight of $\left(\frac{1}{12}\right)^{th}$ of mass of c-12 atom.

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- 2nd Part : **Refer to the solution 2078 of Q. No 3(a) on page 30.**

or)

- ***Steps in the determination of atomic weight.***

i) Determine equivalent weight and specific heat of metal.

ii) Determine approx. atomic weight.

$$\text{Atomics weight} = \frac{6.4}{\text{Specific heat}}$$

iii) Find valency in nearest whole number.

$$\text{Valency} = \frac{\text{Approximate atomic weight}}{\text{Equivalent weight}}$$

iv) Find true atomic weight as;

$$\textbf{Atomic weight} = \textbf{Equivalent weight} \times \textbf{valency}.$$

4) State Avogadro's hypothesis? What is the relationship between Molecular weight and vapour density? Explain.

- **Refer to the solution 2076 of Q. No 3(a) on page 7.**

5) Define equivalent weight of an element. How can you determine equivalent weight by indirect oxide formation method.

- 1st Part: **Refer to the solution 2078 of Q. No 1 (a) on page 27.**

- 2nd Part : **Refer to the solution 2078 of Q. No 5 (b) on page 36.**

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6) 0.0396 gram of metal was completely decomposed in hydrochloric acid and the hydrogen evolved gas mixed with O_2 and sparked to form water. 13.75 cc of dry H_2 at $27°c$ and 680mm kg pressure were required for complete combination. Find the equivalent weight of metal.

➢ **Solution :**

Weight of metal = 0.0396

Volume of H_2 (V_1) = 13.75 cc

Temperature (T_1) = 27 + 273 = 300 K

Pressure (P_1) = 680 mm

A + NTP

Volume of H_2 (V_2) = ?

Temperature (T_2) = 273K

Pressure (P_2) = 760 mm

Using Combined gas Equation,

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$V_2 = \left(\frac{P_1V_1}{T_1}\frac{T_2}{P_2}\right)$$

$$= \left(\frac{680 \times 13.75 \times 273}{300 \times 760}\right)$$

$$\mathbf{V_2 = 11.19cc.\ At\ NTP}$$

Volume of H_2 at NTP = 11.19 cc

Now,

22400cc of H_2 At NTP = 2gm

11.19 cc. of H_2 At NTP $= \frac{2}{22400} \times 11.19$ gm

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$$= \mathbf{9.99 \times 10^{-4} gm}$$

Now, Eq. wt of hydrgen = 1.008

$$\text{Eq. wt of metal} = \frac{\text{Weight of element}}{\text{Weight of hydrogen}} \times \text{Eq. wt of hydrgen}$$

$$= \frac{0.0396}{9.99 \times 10^{-4}} \times 1.008$$

$$\mathbf{Eq.\ wt\ of\ metal = 39.95\ gm}$$

7) What do you mean by acid and base according to Arrhenius concept? Also, explain its limitations.

➢ **Refer to the solution 2076 of Q. No 4 (a) on page 11.**

or) Calculate the $[H^+]$ and $[OH^-]$ in a solution in which 2 gram NaOH are dissolved in 2 liter solution.

➢ **Solution:**

Weight of NaOH = 2gm
Volume (V) = 2 litre
Eq. wt of NaOH = 40 gm

Now,

$$\text{Normality} = \frac{\text{Weight of NaOH}}{\text{Eq. wt} \times \text{Volume (in L)}}$$

$$= \frac{2}{40 \times 2}$$

$$= \mathbf{0.025\ N}$$

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$$\{\text{Since, Normality} = \text{Molarity} \times \left(\frac{\text{Mol. Wt}}{\text{Eq. Wt}}\right)$$

$$\text{Normality} = \text{Molarity} \times \left(\frac{40}{40}\right)$$

$$\text{Molarity} = 0.025\ \text{M}\ \}$$

Or,

[**since, acidity of NaOH is 1**] **Molarity = 0.025 M**

$$\text{NaOH} \xrightarrow{\text{aq}} \text{Na}^+ + \text{OH}^-$$

0.025 M 0.025M

$$[\mathbf{OH^-}] = \mathbf{0.025M}$$

Now, $[\text{H}^+][\text{OH}^-] = 1 \times 10^{-14}$

$$[\text{H}^+] = \frac{1 \times 10^{-14}}{0.025}$$

$$[\mathbf{H^+}] = \mathbf{4 \times 10^{-13}\ M}$$

Hence,

$$[\text{H}^+] = 4 \times 10^{-13}\ \text{M}$$

$$[\text{OH}^-] = 0.025\text{M}$$

8) What do you mean by Normality? Explain the prerequisite of primary standard substances.

- 1st Part: **Refer to the solution 2078 of Q. No 6 (e) on page 39.**
- 2nd Part: **Refer to the solution 2078 of Q. No 6 (f) on page 40.**

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9) What do you mean by electrovalent and covalent bond? Write down the electron dot structure of:

a) H_2SO_4 b) SO_3 c) CH_4

- **Electrovalent bond :** Electrovalent bond is formed by complete transfer of one or more valence electrons from one atom to another.

  For Example : NaCl

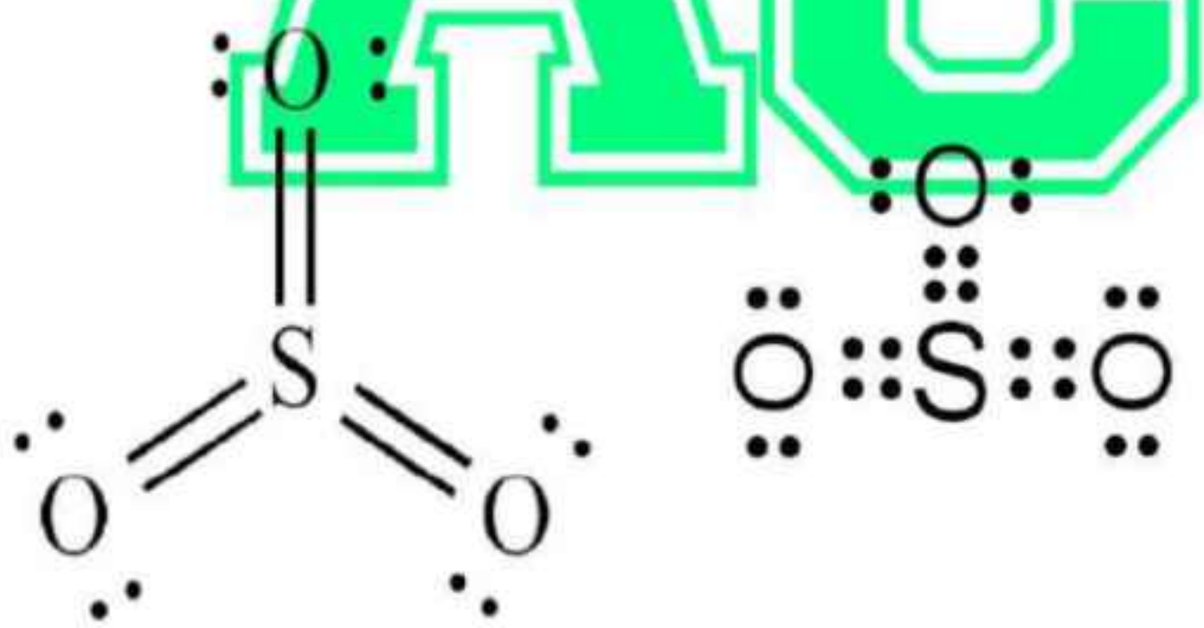
- **Covalent bond:** The bond which is formed between two or more atoms of the same or different elements by equal sharing of electron between any two combining atom is known as *covalent bond*.

  For Example : H_2O

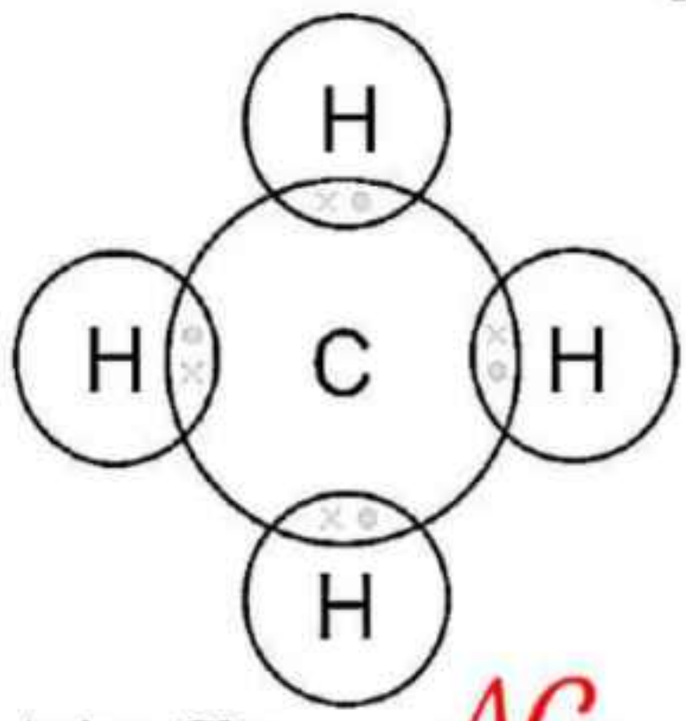
The electron dot structure of H_2SO_4:

- *Refer to the solution 2076 of Q. No 9 (b) on page 22.*

- **The electron dot structure of SO_3:**



- **The electron dot structure of CH_4:**



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10) What do you mean by electrolytes? explain Faraday's First law of electrolysis.

- ***Electrolytes*** are substances which, in the form of a solution in a suitable solvent or in molten state, allow the passage of current and simultaneously undergo chemical transformation.
  For Example: Sodium, calcium, potassium, chloride, phosphate, and magnesium.

- **Refer to the solution 2078 of Q. No 2 (a) on page 28.**

OR) What do you mean by corrosion? Explain the types and prevention of corrosion.

- 1st Part: **Refer to the solution 2080 of Q. No 6 (a) on page 64.**

- **The types of corrosion are :-**

✓ **Uniform corrosion:** This is the most common type of corrosion and occurs when the material is corroded uniformly across its surface.

✓ **Galvanic corrosion**: This type of corrosion occurs when two dissimilar metals are in contact in the presence of an electrolyte, resulting in a flow of electrons from one metal to the other.

✓ **Crevice corrosion**: This occurs in confined spaces where there is limited oxygen flow, such as gaps, seams, or under deposits.

✓ **Pitting corrosion:** This is a localized form of corrosion that produces small holes or pits on the surface of the material.

✓ **Intergranular corrosion:** This type of corrosion occurs along the grain boundaries of metals due to differences in chemical composition.

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Prevention of corrosion :

- 1st Part: **Refer to the solution 2080 of Q. No 10 (d) on page 25.**

11. State Modern periodic law. What are the uses and anomalies of Mendeleev's periodic table?

- 1st part : **Refer to the solution 2076 of Q. No 9 (a) on page 21.**
- 2nd Part: **Refer to the solution 2078 of Q. No 3(b) on page 33.**

12. What do you mean by oxidation and reduction according to classical concept? Explain with example. Also explain oxidation and reduction go side by side.

- 1st part : **Refer to the solution 2080 (Old) of Q. No 4 (a) on page 62.**
- 2nd Part: **Refer to the solution 2079 (New) of Q. No 12 on page 51.**

13) Balance the redox reaction by oxidation number method:-

$$Zn + HNO_3 \longrightarrow Zn(NO_3)_2 + NH_4NO_3 + H_2O$$

- Oxidation

$$\overset{0}{Zn} + \overset{+5}{H}\overset{+2}{N}O_3 \longrightarrow Zn(\overset{+2}{N}O_3)_2 + \overset{-3}{N}H_4NO_3 + H_2O$$

reduction

Increase in oxidation number of Zn $= 2 - 0 = 2$

Decrease in oxidation number of N $= 5 - (-3) = 8$

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Since, there are two products containing nitrogen in product side, writing HNO_3 twice in reactant side.

$$Zn + HNO_3 + HNO_3 \longrightarrow Zn(NO_3)_2 + NH_4NO_3 + H_2O$$

To balance, multiply Zn by 4 and by 1 and balance these elements (Zn, N) in product side.

$$4Zn + HNO_3 + HNO_3 \longrightarrow 4Zn(NO_3)_2 + NH_4NO_3 + H_2O$$

Finally balance the remaining elements;

$$4Zn + HNO_3 + 9HNO_3 \longrightarrow 4Zn(NO_3)_2 + NH_4NO_3 + 3H_2O$$

Therefore, This is balanced equation.

14) Explain Rutherford's atomic model and its drawbacks.

- 1st part: **Refer to the solution 2076 of Q. No 5 (a) on page 13.**
- 2nd part: **Refer to the solution 2076 of Q. No 2 (a) on page 29.**

15) Explain about quantum numbers in detail.

- **Refer to the solution 2079 (New) of Q. No 14 on page 51.**

–The End –

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(2080/81 Old) Question Paper Solution.

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1. a) State Avogadro's hypothesis. Show that the molecular weight of substances is twice of it's vapour density.

- **Refer to the solution 2076 of Q. No 3(a) on page 7.**

b) Define equivalent weight of an metal. 0.212 gms of a reactive metal when dissolved in dil. HCl evolved 218.2 cc of hydrogen at 17°c and 745.5 mm Hg pressure over water. Find the equivalent weight of the metal (Aq. tension at 17°C 14.4 mm Hg).

- 1st Part: **Refer to the solution 2078 of Q. No 1 (a) on page 27.**
- 2nd Part: **Refer to the solution 2079 (New) of Q. No 5(b) on page 46.**

2. a) What down assumptions of electronics theory of valency?

- **Refer to the solution 2076 of Q. No 10 (a) on page 23.**

b) Show the difference between electrovalent and covalent compounds with example.

- **The difference between electrovalent and covalent compounds are:-**

**2 Extra point

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Electrovalent compounds	Covalent compounds
The Compound formed by complete transfer of one or more valence electrons from one atom to another.	The Compound formed by between two or more atoms of the same or different elements by equal sharing of electron between any two combining atom is known as *covalent compound*.
They have high density, melting point and boiling point.	They have low density, melting point and boiling point.
They conduct electricity in the fused or aqueous state.	They do not conduct electricity in the solid, fused or aqueous state.
They are compounds which are hard, brittle crystalline solids consisting of ions.	They are made up of molecules and they are either gases or liquids or soft solids.
For Example : $NaCl, CaO, etc$	***For Example*** : H_2O, HCl, etc

c) State Faraday's first and second law of electrolysis.

- 1st Part: **Refer to the solution 2078 of Q. No 2 (a) on page 28.**

- 2nd Part: **Refer to the solution 2076 of Q. No 8 (a) on page 19.**

3. a) Balance the equation by oxidation number method:-

$$Zn + HNO_3 \longrightarrow Zn(NO_3)_2 + NO + H_2O$$

- **Refer to the solution 2079 (Old) of Q. No 6 (b) on page 57.**

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b) Discuss the Lewis concept of acid and base giving appropriate example.

- *According to Lewis concept"* an ***acid*** is a substance which is capable of *accepting an electron pair* and ***base*** is a substance which is capable of *donating an electron pair*.

For Example:

$$\underset{\text{Acid}}{\mathbf{H^+}} + \underset{\text{Base}}{\mathbf{OH^-}} \longrightarrow \mathbf{H - \ddot{\underset{..}{O}} - H}$$

H^+ is accepting electron pair from OH^- i.e $OH^-$is donating an electron pair.

$$\underset{\text{Acid}}{\mathbf{H^+}} + \underset{\text{Base}}{\mathbf{:NH_3}} \longrightarrow \mathbf{NH^+_4}$$

c) Calculate the P^H of the following solutions:

i) $0.5\ M\ H_2SO_4$

- **Solution:**

H_2SO_4 is a strong electrolyte, so, it ionizes completely.

$$H_2SO_4 \longrightarrow 2H^+ + SO_4^{--}$$

1 mole	2 mole
0.5 mol/lit	$\mathbf{0.5 \times 2}$ **mol/lit**

$\therefore$ Concentration of $[H^+] = 1$ mol/lit.

$\therefore p^H = -\log[H^+] = -\log(1) = 0$

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ii) 0.1 M NaOH

➢ **Solution:**

NaOH is a strong electrolyte, so, it ionizes completely.

$$\underset{\substack{1\text{ mole}\\0.1\text{ mol/lit}}}{NaOH} \longrightarrow Na^+ + \underset{\substack{1\text{ mole}\\0.1\text{ mol/lit}}}{OH^-}$$

$\therefore [OH^-] = 0.1$ mol/lit.

$\therefore p^{OH} = -\log[OH^-] = -\log[0.1] = 1$

$\therefore p^{H} = 14 - 1 = 13$

4. a) Define mole. Find the weight in grams and number of molecules in 0.5 moles of $ca(OH)_2$.

➢ ***Mole** is a unit used to measure the amount of a substance*. One mole of a substance contains the same number of particles as there are in 12 grams of carbon-12. This number is approximately 6.02×10^{23} particles and is known as Avogadro's number.

➢ **Solution:**

Given,

Number of moles of $ca(OH)_2 = 0.5$

Molecular weight of $ca(OH)_2 = 74$ gm

We have,

$$\text{Number of moles} = \frac{\text{Weight in gram}}{\text{Molecular weight}}$$

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$$\text{Weight in gram} = \text{Number of moles} \times \text{Molecular weight}$$
$$= 0.5 \times 74$$
$$= 37$$

$\therefore$ **Weight in gram = 37 gm**

Also,

$$\text{Number of moles} = \frac{\text{Number of molecules}}{6.023 \times 10^{23}}$$

$$\text{Number of molecules} = \text{Number of moles} \times 6.023 \times 10^{23}$$
$$= 0.5 \times 6.023 \times 10^{23}$$
$$= 3.0115 \times 10^{23}$$

$\therefore$ **Number of molecules** $= \mathbf{3.0115 \times 10^{23}}$ ***molecules***

b) State Mendeleev's periodic law and Modern periodic law. What are characteristics of Mendeleev's periodic table?

- 1st part: **Refer to the solution 2078 of Q. No 3(b) on page 33.**
- 2nd part : **Refer to the solution 2076 of Q. No 9 (a) on page 21.**
- ***The characteristics of Mendeleev's periodic table are:-***
  - ✓ The elements are arranged in nine vertical columns known as groups. The ninth one is called zero group.
  - ✓ There are seven horizontal rows known as periods. Six periods are complete whereas seventh one is incomplete.

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- ✓ This table is based on the Mendeleev's periodic law which states, "The physical and chemical properties of all elements are periodic functions of their atomic mass".
- ✓ All the groups except zero and VIII are further divided into subgroups A and B.
- ✓ There are some blank spaces for undiscovered elements.
- ✓ Mendeleev's table helped correct the atomic masses of several chemical elements.
- ✓ Elements were arranged in order of increasing atomic weight.

5. a) What are the postulates of Bohr's atomic model.

➢ **Refer to the solution 2078 of Q. No 2(b) on page 30.**

b) What do you mean by standard solution and unknown solution? 25 cc of N/10 HCl neutralized 21 cc of sodium carbonate solution. How much water must be added to one litre of Na_2CO_3 to make it exactly decinormal solution?

➢ A Solution of known strength is called ***standard solution***.

➢ The solution whose exact strength is unknown is ***unknown solution***.

➢ **Solution:**

Given that,

Volume of HCl $(V_1) = 25$ cc

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Strength of HCl $(S_1) = \frac{N}{10}$

Volume of Na_2CO_3 $(V_2) = 21$ cc

Strength of Na_2CO_3 $(S_2) = ?$

From the principle of volumetric analysis; we have,

$$V_1S_1 = V_2S_2$$

$$S_2 = \frac{V_1S_1}{V_2}$$

$$= \frac{25 \times \frac{N}{10}}{21}$$

$$\therefore \mathbf{S_2 = 0.119\ N}$$

Initial volume of $Na_2CO_3(V_1) = 1000$ cc

Initial strength of Na_2CO_3 $(S_1) = 0.119$ N

Final strength of $Na_2CO_3(S_2) = 0.1$ N

Final volume of Na_2CO_3 $(V_2) = ?$

We have,

$$V_1S_1 = V_2S_2$$

$$V_2 = \frac{V_1S_1}{S_2}$$

$$V_2 = \frac{1000 \times 0.119}{0.1}$$

$$\mathbf{V_2 = 1190\ cc}$$

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So, Amount of water added $= V_2 - V_1$

$= 1190 - 1000$

$= \mathbf{190\ cc}$

6) Write short notes on:

a) Requisites of primary standard substances.

- **Refer to the solution 2078 of Q. No 6 (f) on page 40.**

b) Lowry and Bronsted concept of acid and base.

- **Refer to the solution 2079 (Old) of Q. No 4 (a) on page 55.**

c) Anomalies of Mendeleev's periodic table

- **Refer to the solution 2078 of Q. No 3(b) on page 33.**

d) Quantum number

- **Refer to the solution 2079 (New) of Q. No 14 on page 51.**

e) Postulates of Dalton's atomic theory

- **Refer to the solution 2078 of Q. No 1 (b) on page 27.**

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f) Auto-oxidation

- Reaction in which same agent acts as both oxidizing as well as reducing agent is known as autoxidation. *For example;*

$$H_2O_2 + H_2O_2 \longrightarrow 2H_2O + O_2 \uparrow$$

In this reaction, oxidation number of hydrogen is +1, oxidation number of oxygen in H_2O_2 , H_2O and O_2 are -1, -2 and 0 respectively. Hence in this reaction oxygen is undergoing both oxidation and reduction. H_2O_2 is acting as both oxidizing and reducing agent. This process is called **auto-oxidation.**

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1) What do you mean by formula? Explain the significance of formula with suitable example.

- **Formula** is defined as the brief representation of any substance in terms of symbols. Chemical formula is associated with molecules of compounds or elements. ***There are two types of formula;***
  - ✓ Molecular formula
  - ✓ Emperical formula
- 2nd Part: **Refer to the solution 2080 (New) of Q. No 1 on page 67**

2) What are the essentials of chemical equations? Explain its limitations.

- 1st Part: **Refer to the solution 2080 (New) of Q. No 2 on page 68**
- 2nd Part: **Refer to the solution 2078 of Q. No 5 (a) on page 36.**

3) Explain the modern position of Daltons atomic theory.

- **Refer to the solution 2078 of Q. No 1(b) on page 27.**

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4) Write Avogadro's hypothesis. Explain Dulong's and petit's law.

- 1st Part: **Refer to the solution 2076 of Q. No 3(a) on page 7.**
- 2nd Part: **Refer to the solution 2078 of Q. No 3(a) on page 30.**

5) The specific heat of metal is 0.259 and its equivalent weight is 12 g. What is the exact atomic weight of that metal?

- **Solution:**

Given that,

Specific heat of metal $= 0.259$

Equivalent weight $= 12$ g

Exact atomic weight of metal $=?$

From Dulong's and Petit's law, we have

$$\text{Atomics weight} \times \text{Specific heat} = 6.4 \text{ (approx.)}$$

$$\therefore \text{Atomics weight} = \frac{6.4}{0.29} = \mathbf{24.71}$$

$$\text{Valency} = \frac{\text{Atomic weight}}{\text{Equivalent weight}} = \frac{24.71}{12} = 2.059 \approx \mathbf{2}$$

Now,

$$\text{Exact atomic weight of metal} = \text{Equivalent weight} \times \text{Valency}$$
$$= 12 \times 2$$
$$= \mathbf{24\ g}$$

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6) What do you mean by equivalent weight of metal? How can you determine equivalent weight by indirect oxide formation method?

- 1st Part: **Refer to the solution 2078 of Q. No 1 (a) on page 27.**
- 2nd Part: **Refer to the solution 2078 of Q. No 5 (b) on page 36.**

7) Define buffer solution. Explain Lewis acid base concept with example.

- 1st Part: **Refer to the solution 2080 (old) of Q. No 6 (c) on page 65.**
- 2nd : **Refer to the solution 2080/81 (old) of Q. No 3 (b) on page 79.**

or) Calculate the $[H^+]$ and $[OH^-]$ ion in solution of 4 gram sodium hydroxide are dissolved in 2 litre solution.

- **Solution:**

Weight of sodium hydroxide(NaOH) = 4 gm
Volume (l) = 2 Ltr
Eq. wt of NaOH = 40 gm

Now,

$$\text{Normality} = \frac{\text{Weight of NaOH}}{\text{Eq. wt} \times \text{Volume (in L)}}$$

$$= \frac{4}{40 \times 2}$$

$$= \mathbf{0.05\ N}$$

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$$\{\text{Since, Normality} = \text{Molarity} \times \left(\frac{\text{Mol. Wt}}{\text{Eq. Wt}}\right)$$

$$\text{Normality} = \text{Molarity} \times \left(\frac{40}{40}\right)$$

$$\text{Molarity} = 0.05\ \text{M}\ \}$$

Or,

$$[\ \textbf{since, acidity of NaOH} = \textbf{1 so,} \Longrightarrow \textbf{0.05 M}\ ]$$

$$\text{Molarity} = 0.05\ \text{M}$$

$$\text{NaOH} \xrightarrow{aq} \text{Na}^+ + \text{OH}^-$$

0.05 M 0.05M

$$[\mathbf{OH^-}] = \mathbf{0.05M}$$

Now, $[\text{H}^+][\text{OH}^-] = 1 \times 10^{-14}$

$$[\text{H}^+] = \frac{1 \times 10^{-14}}{0.05}$$

$$[\mathbf{H^+}] = \mathbf{2 \times 10^{-13}\ M}$$

Hence,

$$[\text{H}^+] = 2 \times 10^{-13}\ \text{M}$$

$$[\ \text{OH}^-\ ] = 0.05\text{M}$$

8) What do you mean by molarity? Mention the characteristics of primary standard solution.

- 1st Part: **Refer to the solution 2079 (New) of Q. No 8 on page 48.**
- 2nd Part: **Refer to the solution 2078 of Q. No 6 (f) on page 40.**

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9) What do you mean by electrovalent bond? Write down the electron dot structure of H_2SO_4, NH_3 and Cl_2.

- ***Electrovalent bond*** is formed by complete transfer of one or more valence electrons from one atom to another. **For Example : NaCl.**

The electron dot structure of H_2SO_4:

- *Refer to the solution 2076 of Q. No 9 (b) on page 22.*

The electron dot structure of NH_3:

- *Refer to the solution 2079(New) of Q. No 9 (b) on page 49.*

The electron dot structure of Cl_2:

10) What do you mean by electrolysis? Calculate the mass of copper deposited by electrolysis on passing 1.5 A current in 30 minutes through the solution of $CuSO_4$. (At. wt. of Cu 63.5)

- The process of chemical decomposition of an electrolyte in solution or molten state by the passage of electric current is called ***electrolysis.*** The principle of electrolysis is used in electroplating and electrolytic refining.

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➢ **Solution:**

Given here,

Current (I) = 1.5 A

Time (t) = 30 min = 30 × 60 = 1800 sec.

Atomic weight of copper = 63.5 gm

Deposited Mass (m) = ?

We know that, from faraday's first law,

Mass deposited (m) = Zit

$$\mathbf{m = \frac{E}{F}\ It}$$

or, $m = \frac{31.75}{96500} \times 1.5 \times 1800$ $\left(\because \text{In } CuSO_4 \text{ Solution; Equivalent weight of Cu} = \frac{63.5}{2} = 31.5\right)$

$\therefore m = 0.88$ gm

Thus,

Mass of Cu deposited (m) = 0.88 gm

Or) Explain Faraday's first law of electrolysis.

➢ **Refer to the solution 2078 of Q. No 2 (a) on page 28.**

11) State modern periodic law. What are the uses and anomalies of Mendeleev's periodic table?

➢ 1st part : **Refer to the solution 2076 of Q. No 9 (a) on page 21.**

➢ 2nd Part: **Refer to the solution 2078 of Q. No 3(b) on page 33.**

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12) Define redox reaction. Explain classical concept of oxidation and reduction.

- The reaction in which both oxidation and reduction goes side by side is called ***redox reaction.***

- 2nd part : **Refer to the solution 2080 (Old) of Q. No 4 (a) on page 62.**

13) Balance the following equation of oxidation number Method.

$$Zn + HNO_3 \longrightarrow Zn(NO_3)_2 + NO + H_2O$$

- **Refer to the solution 2079 (old) of Q. No 6 (b) on page 57.**

14) Explain Rutherford's atomic model and it's limitation.

- 1st part: **Refer to the solution 2076 of Q. No 5 (a) on page 13.**

- 2nd part: **Refer to the solution 2076 of Q. No 2 (a) on page 29.**

15) What are main postulates of Bohr's atomic model? Explain.

- **Refer to the solution 2078 of Q. No 2(b) on page 30.**

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