10+2 PCM NOTES

BY

JOYOSHISH SAHA

(PDF version handwritten notes of Maths, Physics and Chemistry for 10+2 competitive exams like JEE Main, WBJEE, NEST, IISER Entrance Exam, CUCET, AIPMT, JIPMER, EAMCET etc.)

10+2

Downloaded from https://plustwopcm.blogspot.in/
Visit the blog to get helpful notes for your 10+2 preparation.

With best wishes from Joyoshish Saha

Mole Concept & Stoichiometry

* The mole : The amount of substance containing as many atoms, molecules, ions, electrons or other elementary entities as there are carbon atoms in exactly 12 g of C^{12}. [$N_A = 6.022 \times 10^{23}$]

* In modern practice, a gram-molecule and a gram-atom are termed as a mole of molecules a mole of atoms respectively. Gram-equivalent shall be written as equivalent.

* No. of moles of molecules = $\frac{\text{Weight in g}}{\text{molecular weight}}$

No. of moles of atoms = $\frac{\text{weight in g}}{\text{atomic weight}}$

No. of moles of gases = $\frac{\text{Volume at STP}}{\text{Standard Molar Volume}}$
(SMV $\longrightarrow$ 22.4 lit)

No. of moles of atoms/molecules/ions/electrons = $\frac{\text{no. of elementaries}}{N_A}$

No. of moles of solute = molarity × vol. of solⁿ in litres

No. of milimoles = molarity × vol. in mL.

• milimoles = 1000 × moles.

• for a compound M_xN_y,

x moles of N = y moles of M.

* 1 mole is a fixed number of particles, not a fixed weight.

Joyoshish Saha

* Principle of Atom Conservation (POAC)

In a chemical equation the number of atoms is always constant, atoms are conserved for individual element (N, O, S ... etc)

* Average molecular weight of any non-reacting gaseous mixture:

- When percentage composition is given by volume,

$$M_{mix} = \frac{\Sigma(\text{volume percent} \times \text{mol. wt.})}{100}$$

(for the non-reacting gaseous mixture, the composition by volume & mole are identical).

- When percentage composition is given by weight,

$$\frac{100}{M_{mix}} = \Sigma\left(\frac{\text{weight percent}}{(\text{mol. wt.})}\right).$$

* Vapour density: Ratio of the density of a substance to the density of hydrogen gas under identical conditions of temperature & pressure.

When vapour density is given with respect to hydrogen, it is half of the molecular weight.

* The degree of dissociation of a gaseous substance is given as, $\alpha = \frac{M_0 - M}{(n-1)M}$ [$M_0 \rightarrow$ mol. wt. of original compound, $M \rightarrow$ avg. mol. wt. of gaseous mixture formed, $n \rightarrow$ number of moles of different gaseous substances formed from each mole of compound dissociated].

* Avogadro's Hypothesis: Under identical conditions of pressure & temperature, equal volumes of all the gases contain equal number of molecules.

Joyoshish Saha

Mole concept & Stoichiometry.

* Percentage composition of an element =

$$\frac{Z \times A}{M} \times 100\%$$

Z → no. of atoms of the element in the molecule.

A → atomic weight of the element

M → mol. wt. of the compound.

* Molecular formula = n (empirical formula).

* The number of molecules in 1 cc of gas at STP is equal to Loschmidt number, that is, 2.68×10^{19}.

* Reciprocal of Avogadro number is known as Avogram.

* A mole of any substance (like N_2) stands for –
  1) 6.022×10^{23} molecules of N_2
  2) $6.022 \times 10^{23} \times 2$ atoms of Nitrogen
  3) 28 g of Nitrogen
  4) 22.4 L of N_2 at STP.

* Atomic mass = Equivalent wt. × Valency.

$$\text{Atomic mass} = \frac{6.4}{\text{Specific heat in cal.}}$$ [Dulong-Petit's Law]

* Determination of molecular mass:

a) Vapour density method:

$$\text{VD of gas} = \frac{\text{Wt. of V L of gas}}{\text{Wt. of V L of } H_2 \text{ at same condition}}$$

Joyoshish Saha

$$VD = \frac{\text{Wt. of } n \text{ molecules of gas}}{\text{Wt. of } n \text{ molecules of } H_2}$$ [V L of gas contains n molecules]

$$= \frac{\text{Wt. of 1 molecule of gas}}{\text{Wt. of 1 molecule of } H_2}.$$

$$= \frac{1}{2} \frac{\text{Wt. of 1 molecules of gas}}{\text{Wt. of 1 atom of Hydrogen}}$$

$$VD = \frac{1}{2} M$$

$\Rightarrow$ Molecular mass $= 2 \times VD$.

b) Graham diffusion method:

$$r_1/r_2 = \sqrt{(M_2/M_1)}.$$

c) By colligative property:

$$\pi V = \frac{W}{M} RT.$$

[$\pi \rightarrow$ osmotic pres. (atm)
$V \rightarrow$ Volume (L)
$W \rightarrow$ Wt (g)
$M \rightarrow$ Mol. mass].

* Equivalent Weight: Weight of an element or a compound which combines with or displaces 1.008 part by weight of H_2 or 8 part by weight of O_2 or 35.5 part by weight of Cl_2.

- Eqv. wt. is a number & when expressed in grams, it is called gram equivalent.
- It depends upon the nature of chemical reaction in which substance takes part.

Joyoshish Saha

- Methods for finding eqv. wt. :

a) For acids : $E = \frac{\text{Mol. wt.}}{\text{Protocity or Basicity of acid.}}$

eg. for H_2SO_4, $E = \frac{M}{2}$

b) For bases : $E = \frac{\text{Mol. wt.}}{\text{Acidity or no. of } OH^- \text{ ions.}}$

eg. for $Al(OH)_3$, $E = \frac{M}{3}$.

c) For ions : $E = \frac{\text{Mol. wt.}}{\text{Charge on ion}}$

eg. for SO_4^{2-}, $E = \frac{M}{2}$.

d) For compounds : $E = \frac{\text{Mol. wt.}}{\text{Valency of cation or anion}}$

eg. for $CaCO_3$, $E = \frac{M}{2}$.

e) For redox reactions : $E = \frac{\text{Mol. wt.}}{\text{Change in oxidation number.}}$

eg. for $KMnO_4$,

i) In acidic medium, $E = \frac{M}{5}$.

$$K\overset{+7}{Mn}O_4 + 3H_2SO_4 \rightarrow K_2SO_4 + 2\overset{+2}{Mn}SO_4 + 3H_2O + 5[O]$$

ii) In basic medium, $E = M$.

$$2K\overset{+7}{Mn}O_4 + 2KOH \rightarrow 2K_2\overset{+6}{Mn}O_4 + H_2O + [O].$$

iii) In neutral medium, $E = \frac{M}{3}$.

$$2K\overset{+7}{Mn}O_4 + H_2O \rightarrow 2KOH + 2\overset{+4}{Mn}O_2 + 3[O].$$

Joyoshish Saha

f) For acidic salt: $E = \frac{\text{Mol. wt.}}{\text{No. of replacable H-atoms.}}$

eg. for H_3PO_4

$$Ca(OH)_2 + H_3PO_4 \longrightarrow CaHPO_4 + 2H_2O$$

$$E = M/2.$$

g) Other methods:

i) Hydrogen displacement method:

$$E = \frac{W \times 11200}{\text{Vol. of } H_2 \text{ at STP.}}$$

ii) Oxide formation method:

$$E = \frac{\text{Wt. of metal}}{\text{Wt. of Oxygen}} \times 8.$$

(Wt. of oxygen = Wt. of metal oxide − Wt. of metal).

iii) Chloride formation method:

$$E = \frac{\text{Wt. of metal}}{\text{Wt. of Chloride}} \times 35.5.$$

(Wt. of chloride = Wt. of metal chloride − wt. of metal).

iv) Double decomposition method:

$$\frac{E \text{ of salt taken}}{E \text{ of salt ppt.}} = \frac{\text{Wt. of salt taken}}{\text{Wt. of salt ppt.}}$$

v) Metal displacement methods:

$$\frac{E_1}{E_2} = \frac{W_1}{W_2}.$$

Joyoshish Saha

* Empirical Formula: Simplest ratio of the number of atoms of different elements present in one molecule of a compound. It doesn't represent the actual no. of atoms of different elements present in one molecule of compound.

- Calculation of Empirical formula:

1. Determination of percentage composition by weight of each element present in compound.

$$C\% = \frac{12}{44} \times \frac{\text{Wt. of } CO_2}{\text{Wt. of Org. comp.}} \times 100$$

$$H\% = \frac{2}{18} \times \frac{\text{Wt of } H_2O}{\text{Wt. of org. comp.}} \times 100.$$

- Duma's Method:

$$N\% = \frac{28}{22400} \times \frac{\text{Vol. at STP of } N_2}{\text{Wt. of org. comp.}} \times 100.$$

$$N\% = \frac{1}{8} \times \frac{\text{Vol. of } N_2 \text{ at STP}}{\text{Wt. of org. comp.}}$$

- Kjeldahl's Method:

$$N\% = \frac{1.4 \times N \times V}{\text{Wt. of org. comp.}}$$

[N → normality of acid that used to neutralise NH_3

V → Volume of acid used to neutralise NH_3].

Joyoshish Saha

2. Now, the percentage of each element is divided by its atomic wt to get the relative no. of atoms of each element.

3. These relative no. obtained are divided by smallest number to get the simplest ratio numbers.

4. If simplest ratio number is not a whole number it should be multiplied by a suitable integer to get a whole no.

5. The ratio of these simple whole numbers gives the empirical formula of the compound.

* Expression of concentration of solution:

1. Concentration: It is the amount of solute present in one litre of solution. $C = N \times E$ [normality $\rightarrow N$, $E \rightarrow$ eqv. wt.]

$$C = \frac{\text{Wt. of solute in gram}}{\text{Volume in Litre.}}$$

2. Molarity: $M = \dfrac{\text{No. of moles of solute}}{\text{Volume of solution in L}}$

[molar $sol^n \rightarrow M = 1$, decimolar $sol^n \rightarrow M = 0.1$]

- Molarity depends upon temperature.
- $M_1V_1 = M_2V_2$.
- When the sol^n of different substances react together then $\dfrac{M_1V_1}{n_1} = \dfrac{M_2V_2}{n_2}$

Joyoshish Saha

M, V, n are molarity, volume & number of molecules taking part in a reaction.

- When a mixture of different solutions having different concentrations are taken the molarity of mixture is

$$M = \frac{M_1V_1 + M_2V_2 + \cdots}{V_1 + V_2 + \cdots}$$

- When density & % by weight of a substance in a solution are given molarity is

$$M = \frac{(\% \text{ by weight}) \times d \times 10}{\text{Molecular weight}}.$$

3. Molality : $\frac{\text{No. of moles of solute}}{\text{Wt. of solvent in kg}}$

- One molal sol^n is less than one molar sol^n.

- Molality is preferred over molarity during experiments as molality is temperature independent while molarity is temperature dependent.

4. Normality : $N = \frac{\text{no. of gram eqv's of solute}}{\text{Vol. of solution in L.}}$

- $N_1V_1 = N_2V_2$.

- $N = \frac{(\% \text{ by wt.}) \times d \times 10}{\text{Eqv. Wt.}}$

- Normality of mixture, $N = \frac{N_1V_1 + N_2V_2 + \dots}{V_1 + V_2 + \dots}$

- In case of acid-base neutralization the normality of the resulting solution

$$N = \frac{N_1V_1 - N_2V_2}{V_1 + V_2}.$$

- Wt. of substance, $W = \frac{NEV}{1000}$

- Normality × Eq. Wt. = Molarity × Molecular wt.

$NE = Mm.$

$N = M \times$ Valency

$N = M \times$ no. of H^+ or OH^- ion.

5. Mole fraction:

$$\frac{\text{no. of moles of element}}{\text{Total no. of moles}}$$

- Mole fraction doesn't depend upon temp.

* Limiting reagent: Reactant that is present in minimum stoichiometry quantity for a chemical reaction. It is reactant consumed fully in a chemical reaction. All calculation related to various products or in sequence of reactions are made on the basis of limiting reagent.

- To get the limiting reagent, divide given moles of each reactant by their stoichiometric coefficient, the one with least ratio is LR.

Joyoshish Saha

* Gravimetric Analysis:

1. Problems involving mass - mass or weight - weight relationship:

a) Write the balanced equation. b) Write the number of moles below the formula of the reactants & product. Write the relative wt.s. c) Apply unitary method.

2. Problems involving mass - volume or weight - volume relationship:

a) Write the balanced equ^n. b) Write the weights of various reactants & products. c) Express the volume of gas at STP. d) Weight of gas can be obtained $PV = \frac{W}{M}RT$. d) Calculate unknown factor. [STP → 760 mmHg, 273K.]

3. Problems involving volume - volume relationship:

a) Write balanced equ^n. b) Write volumes of reactants and products (STP). c) Convert to STP volume, if not. d) Use Avogadro's hypothesis.

* n - factor or Valence Factor:

- Calculation:

1. Acid - base or Neutralisation Reactions:

The number of H^+ & OH^- ions represent n - factor for acid & base.

Joyoshish Saha

2. Redox Reactions: Finding out change of oxidation state.

eg. Follow different kinds of redox reaction & how to calculate n-factor for them.

a) $\overset{+3}{C_2}O_4^{2-} \rightarrow 2\overset{+4}{C}O_2$

n-factor, $n = |(+4)\times 2 - (+3)\times 2| = 2$

b) $\overset{+6}{Cr_2}O_7^{2-} \rightarrow Cr^{3+} + Cr^{3+}$

$n = |(+3)\times 2 - (+6)\times 2| = 6$

c) $3\overset{+7}{Mn}O_4^- \rightarrow 2\overset{+2}{Mn}^{2+} + Mn^{6+}$

$$n = \frac{|(+2)\times 2 - (+7)\times 2| + |(+6)\times 1 - (+7)\times 1|}{3} = \frac{11}{3}.$$

d) $K_2Cr_2O_7 + 14H\overset{-1}{Cl} \rightarrow 2K\overset{-1}{Cl} + 2Cr\overset{-1}{Cl_3} + 3\overset{0}{Cl_2} + 7H_2O$

loss of electron → 6 by 14 HCl molecule.

$n = \frac{6}{14} = \frac{3}{7}$. [n factor of HCl].

e) $\overset{+2}{Fe}\overset{+3}{C_2}O_4 \rightarrow Fe^{3+} + 2\overset{+4}{C}O_2$

$n = |(+3)\times 1 - (+2)\times 1| + |(+4)\times 2 - (+3)\times 2|$

$= 3.$

f) $2K\overset{+5}{Cl}\overset{-2}{O_3} \rightarrow 2K\overset{-1}{Cl} + 3\overset{0}{O_2}$

$n = [|(-1)\times 2 - (+5)\times 2|]/2 = 6$ for reduction

or, $n = [|0\times 3 - (-2)\times 6|]/2 = 6.$ for oxidation

Joyoshish Saha

g) $2H_2\overset{-1}{O}_2 \longrightarrow 2H_2\overset{-2}{O} + \overset{0}{O}_2$ [Disproportion reaction].

$n = |(-2)\times 2 - (-1)\times 2| = 2.$ for reduction

or, $n = |0 - (-1)\times 2| = 2.$ for oxidation

* h) $6\overset{0}{X}_2 + 12OH^- \rightarrow 10X^- + 2\overset{+5}{X}O_3^- + 6H_2O.$

Oxidation $\overset{0}{X}_2 \longrightarrow 2\overset{+5}{X} + 10e^-$

Reduction $5\overset{0}{X}_2 \longrightarrow 10X^- - 10e^-$

$n_{ox} = |(+5)\times 2 - 0| = 10$

$n_{red} = [|(-1)\times 10 - 0|]/5 = 2.$

n-factor of X_2 as oxidising & reducing agent is 2 & 10.**

3. Precipitation or double decomposition reaction:

$BaCl_2 + K_2SO_4 \rightarrow BaSO_4 + 2KCl$

For $BaCl_2$, $n = ($Ox. state of Ba in $BaCl_2$ × no. of Ba atoms in one molecule of $BaCl_2) = (+2)\times 1 = 2$

For K_2SO_4, $n = ($OS of K in K_2SO_4 × no. of K atoms in one molecule of $K_2SO_4) = (+1)\times 2 = 2.$

* Laws of Equivalence: Equivalent of each reactant reacted = Equivalent of each product formed.

$$P + Q \rightarrow R + S.$$

eqv of P reacted =

eqv of Q reacted

= eqv of R formed

= eqv of S formed.

- eqv. of substance = $\frac{\text{Weight in gram}}{\text{Eqv. wt.}}$

= Normality × volume

Normality = n factor × molarity.

* Volumetric Analysis (Titration): Analytical method used to find the concentration of a substance in a solution by adding exactly same number equivalents of some other substance present in a solution of known concentration.

Substance, whose solution is used to find the concentration of unknown solution is known as titrant and the ~~solution~~ substance whose concentration is to be calculated is titrate.

Joyoshish Saha

* Types of Titration:

1. Simple Titration: Known volume of the solution of unknown concentration is taken in a flask & essential reagents are taken. Now, sol^n of known conc. is added from the burette in the solution till complete reaction occurs between them & the equivalence points are equal.

If X & Y solutions are taken,

$N_X V_X = N_Y V_Y$ | N → Normality, V → Volume.

2. Double Titration: Used for various compounds using specific indicators.

3. Back Titration: Used to find out percentage impurity of sample

4. Iodimetric Titration:

5. Iodometric Titration.

Joyoshish Saha

* Volume strength of H_2O_2 solution: If a sample of H_2O_2 is labelled as x volume, it means that 1 volume of H_2O_2 solution gives x volume of O_2 gas at STP on complete decomposition.

$$\text{Volume strength of } H_2O_2 = 5.6 \times \text{Normality}.$$

* Percentage Labelling of Oleum:

% labelling of Oleum = Total mass of H_2SO_4 present in Oleum after dilution.

= mass of H_2SO_4 initially present + mass of H_2SO_4 produced after dilution

* Hardness of Water: $\dfrac{\text{gm of } CaCO_3}{10^6 \text{ g of } H_2O}$

* $CuSO_4 \cdot 5H_2O$, $Na_2CO_3 \cdot 10H_2O$ are efflorescent (tend to lose water).

NaOH, KOH are Deliquescent (tend to absorb moisture). CaO, P_2O_5 absorb moisture (Hygroscopic substance).

* In Redox titration: Oxidising agent → O
Reducing agent → R

$$V_O \times M_O = V_R \times M_R \times \frac{\text{No. of moles of O}}{\text{No. of moles of R.}}$$

In acid-base titration:

$$V_{acid} \times M_{acid} = V_{base} \times M_{base} \times \frac{\text{No. of moles of acid}}{\text{No. of moles of base.}}$$

Joyoshish Saha

* Victor Mayer's Process :

Known weight (W) of volatile substance converted to vapour & collected over water. Volume of air displaced over water is V,

$$M = \frac{W}{PV} RT \quad \text{or} \quad M = \frac{W}{(P-P')V} RT$$

If aq. tension not given If aq. tension is P'

* Silver Salt Method (for organic acids):

Some known amount of silver salt (W_1 g) is heated to obtain W_2 g of white shining residue of silver. Then if the basicity of acid is n

$$\left(\frac{W_2}{108} \times \frac{1}{n}\right) M_{salt} = W_1 \quad \& \quad M_{acid} = M_{salt} - n(107).$$