



CHEMISTRY XII

MOST EXPECTED QUESTIONS

2083

With Solution

Prepared By:
Faculty of Chemistry

Chapter 1: Volumetric Analysis

Note: In some questions, only a specific component (such as the definition of a term) may be required. Students should respond only to the part explicitly asked in the question.

1. Derive the relation between atomic weight, equivalent weight and valency.

Solution

Atomic weight (A): Atomic weight is the mass of one atom of an element compared to $\frac{1}{12}$ the mass of one atom of Carbon-12.

Equivalent weight (E): Equivalent weight of an element is the mass of the element which combines with or displaces: either 1 gram of hydrogen, or 8 grams of oxygen or 35.5 grams of chlorine.

Valency (V): Valency is the combining capacity of an element.

Derivation:

Let, atomic weight of an element = A

Valency of the element = V

If the valency of the element is V, it means: 'A' grams of the element combine with 'V' grams of hydrogen (since valency of hydrogen = 1)

Therefore,

Mass of the element that combines with 1 gram of hydrogen is: $\frac{A}{V}$

But by definition, the mass of an element that combines with 1 gram of hydrogen is called its equivalent weight. Hence,

$$E = \frac{A}{V}$$

$$\text{i.e., Equivalent weight} = \frac{\text{Atomic weight}}{\text{Valency}}$$

2. Define equivalent weight of (i) Acid (ii) Base (iii) Salt (iv) Oxidizing and reducing agent

Solution

(i) Equivalent weight of an Acid

It is defined as the mass of the acid that furnishes 1 mole of replaceable H^+ (1 gram of hydrogen ion) in a chemical reaction. i.e.,

$$\text{Equivalent weight of acid} = \frac{\text{Molar mass}}{\text{Basicity}}$$

Where, Basicity = number of replaceable H^+ ions per molecule of acid.

(ii) Equivalent weight of a Base

It is defined as the mass of the base that furnishes 1 mole of OH^- (or neutralizes 1 mole of H^+).

$$\text{Equivalent weight of base} = \frac{\text{Molar mass}}{\text{Acidity}}$$

Where, Acidity = number of replaceable OH^- ions per molecule of base.

(iii) Equivalent weight of a Salt

It is defined as the mass of the salt that reacts with or is equivalent to 1 mole of H^+ or OH^- in a reaction.

$$\text{Equivalent weight of salt} = \frac{\text{Molar mass}}{\text{Total positive or negative valency}}$$

(iv) Equivalent weight of Oxidizing and Reducing Agent

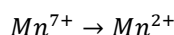
It is defined as the mass of the substance that gains or loses 1 mole of electrons in a redox reaction.

$$\text{Equivalent weight} = \frac{\text{Molar mass}}{\text{Number of electrons gained or lost}}$$

3. Calculate the equivalent weight of (i) KMnO_4 in various medium (ii) $\text{K}_2\text{Cr}_2\text{O}_7$ in acidic and basic medium.

Solution**(i) Molecular mass of $\text{KMnO}_4 = 158$**

Equivalent weight (E) = $\frac{\text{Molar mass}}{\text{n-factor}}$, where, n-factor = no. of electrons gained per molecule.

a. In Acidic Medium

Change in oxidation number: $+7 \rightarrow +2$

Electrons gained = 5

$$\text{So, } E = \frac{158}{5} = 31.6$$

b. In Neutral Medium

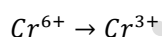
Change in oxidation number: $+7 \rightarrow +4$

Electrons gained = 3

$$E = \frac{158}{3} = 52.67$$

(ii) Equivalent weight of $\text{K}_2\text{Cr}_2\text{O}_7$

Molar mass of $\text{K}_2\text{Cr}_2\text{O}_7 = 294$

a. In Acidic Medium

Change in oxidation number per Cr: $+6 \rightarrow +3$

Change = 3 electrons

Since, there are 2 Cr atoms, $3 \times 2 = 6$ electrons

$$E = \frac{294}{6} = 49$$

b. In basic Medium

In basic medium, dichromate converts to chromate (no redox change)

Cr oxidation state remains +6.

So, n-factor = 0 (no reduction)

Hence, $\text{K}_2\text{Cr}_2\text{O}_7$ does not act as oxidizing agent in basic medium.

4. Define: (i) % $\frac{w}{v}$ (ii) % $\frac{w}{w}$ (iii) % $\frac{v}{v}$

Solution

(i) % w/v (Percentage weight by volume)

It is defined as the number of grams of solute present in 100 mL of solution.

$$\% \text{ w/v} = \frac{\text{Mass of solute (g)}}{\text{Volume of solution (mL)}} \times 100$$

Example: If 5g of sugar is dissolved to make 100 mL solution,

$$\% \text{ w/v} = 5\%$$

5. Define: (i) gm/litre (ii) Normality (iii) Molarity (iv) Molality

Solution

(i) gm/litre: It is defined as the number of grams of solute present in one litre (1000 mL) of solution.

$$g/L = \frac{\text{Mass of solute in grams}}{\text{Volume of solution in litres}}$$

(ii) Normality: The number of gram equivalent of a solute is present in one litre of solution is called normality.

(iii) Molarity: The number of gram mole of a solute is present in one litre of solution is called molarity.

(iv) Molality: Molality is a property of a solution and is defined as the number of moles of solute per kilogram of solvent. The SI unit of molality is mol/kg.

6. Show that: (i) $\% \left(\frac{w}{v}\right) \times 10 = \frac{gm}{lit}$ (ii) $w = \frac{V \times E \times N}{1000}$ (iii) $w = \frac{(V \times Mol.wt. \times M)}{1000}$

Solution

(i) $\% \left(\frac{w}{v}\right) \times 10 = \frac{gm}{lit}$

By definition, $\% \left(\frac{w}{v}\right) = \frac{\text{Mass of solute (g)}}{\text{Volume of solution (mL)}} \times 100$

If a solution is x% (w/v), it means, x g solute in 100 mL solution

Now, converting 100 mL to 1 litre (1000 mL):

$$\text{Mass in 1000 mL} = \frac{x}{100} \times 1000 = 10x$$

$$\text{So, } g/L = 10 \times \% \left(\frac{w}{v}\right)$$

$$\text{Or, } \% \left(\frac{w}{v}\right) \times 10 = g/L$$

(ii) $w = \frac{V \times E \times N}{1000}$

We know,

$$N = \frac{\text{gram equivalent}}{\text{Volume in litre}}$$

$$\text{But, gram equivalent} = \frac{w}{E}$$

$$\text{So, } N = \frac{w/E}{V/1000}$$

$$\text{Or, } N = \frac{1000w}{E \times V}$$

$$\text{Or, } w = \frac{V \times E \times N}{1000}, \text{ where, } w = \text{weight of solute (g), } V = \text{volume (mL), } E = \text{equivalent weight, } N = \text{normality}$$

(iii) $w = \frac{V \times \text{Molecular weight} \times M}{1000}$

$$\text{We know, } M = \frac{\text{moles}}{\text{Volume in litre}}$$

$$\text{But, moles} = \frac{w}{\text{Molecular weight}}$$

$$\text{So, } M = \frac{w/\text{Mol.wt}}{V/1000}$$

$$\text{Or, } M = \frac{1000w}{\text{Mol.wt} \times V}$$

$$\text{Or, } w = \frac{V \times \text{Mol.wt} \times M}{1000}$$

7. Define:

- | | |
|---------------------------|--|
| a. Normal Solution | b. Decinormal solution |
| c. Molar solution | d. Decimolar solution e. ppm |

Solution

a. Normal Solution:

A solution containing one gram equivalent of solute present in one litre of solution is called normal solution.

b. Decinormal Solution:

The solution in which one tenth gram equivalent of solute is dissolved to prepare one litre solution is called decinormal solution. It is denoted by $\frac{N}{10}$. Example: 4g of NaOH solution is dissolved to prepare 1 L solution, the strength of solution is decinormal.

c. Molar Solution

It is a solution that contains one mole of solute dissolved in one litre (1000 mL) of solution. It is expressed in terms of molarity (M).

$$M = \frac{\text{Number of moles of solute}}{\text{Volume of solution in litre}}$$

d. Decimolar Solution:

The solution in which one tenth mole of solute is dissolved to prepare one litre solution is called decimolar solution. It is denoted by $\frac{M}{10}$. Example: 9.8 g of sulphuric acid is dissolved to prepare 1 L solution; the strength of solution is decimolar.

e. ppm (Parts Per Million)

ppm (parts per million) is the number of parts of solute present in one million parts of solution.

$$\text{ppm} = \frac{\text{Mass of solute}}{\text{Mass of solution}} \times 10^6$$

8. Define primary standard substance and secondary standard substance.

Solution

Primary standard substance: The substance whose standard solution can be prepared directly by dissolving the known weight of substance in certain volume of solution is called primary standard substance and the solution made from primary standard substance is called primary standard solution. Example: solution of oxalic acid.

Secondary standard substance: The substance whose strength is to be determined with the help of primary standard substance is called secondary standard substance and the solution made from secondary substance is called secondary standard substance. Example: solution of NaOH.

9. What are the criteria for the substance to become primary standard?

Solution

Two major criteria for the substance to become primary standard are:

- It shouldn't be more hygroscopic and affected by moisture of the atmosphere.
- It shouldn't have high atomic weight and equivalent weight.
- The substance must be easy to obtain and purity.
- The composition should not change during storage or weighing.

10. Differentiate between primary standard solution and secondary standard solution.**Solution**

Primary standard solution	Secondary standard solution
It is prepared by dissolving pure substance which is not affected in its composition for a long time.	It is prepared by neutralizing against the primary standard solution.
Example: Oxalic acid, Na ₂ CO ₃ , AgNO ₃ , KCl, etc.	Example: NaOH, HCl, H ₂ SO ₄ , HNO ₃ , KMnO ₄ , etc.

11. Derive the relation between Normality and Molarity.**Solution**

Normality (N): If the equivalent weight of a substance is expressed in gram is called gram equivalent. It is defined as the number of gram equivalent of a solute present in one liter of I's solution. It is denoted by "N".

$$\begin{aligned} \text{Normality (N)} &= \frac{\text{No. of gram equivalent weight of solute}}{\text{Volume of solution in litre}} \\ &= \frac{\text{Weight of solute in g}}{\text{Equivalent weight of solute}} \times \frac{1000}{\text{Volume of solution in mL}} \end{aligned}$$

Normality is related with molarity as

$$\text{Normality (N)} = \text{molarity (M)} \times \text{basicity of acid or acidity of base}$$

12. State the law of chemical equivalence and hence derive normality equation.**Solution****Normality Equation**

According to the law of equivalent

$$\text{No. of gram equivalent of acid} = \text{no. of gram equivalent of base}$$

Normality of a solution is defined as:

$$\text{Normality} = \frac{\text{No. of gram equivalent of solute}}{\text{volume in a liter of a solution volume in a liter of a solution}}$$

At the equivalent of point,

$$\text{No. of gram equivalent of acid} = \text{no. of gram equivalent of base}$$

$$\text{Or, Normality of acid} \times \text{volume in L of acid} = \text{Normality of base} \times \text{volume in L of base}$$

$$\text{Or, Normality of acid} \times 1000 \times \text{volume in mL of acid} = \text{Normality of base} \times 1000 \times \text{volume in mL of base}$$

$$\text{Or, Normality of acid} \times \text{volume in mL of acid} = \text{Normality of base} \times \text{volume in mL of base}$$

$$\text{Or, } N_1 V_1 = N_2 V_2$$

Where, V₁ = Volume of acid, V₂ = Volume of base, N₁ = Normality of acid, N₂ = Normality of base

13. Define Normality factor. What is the significance of normality factor in titration?

Solution

Normality factor: It is the ratio of observed weight of substance and theoretical weight of substance.

$$\text{Normality factor (f)} = \frac{\text{Observed weight}}{\text{Theoretical weight}}$$

14. Define the terms: (i) Indicator (ii) Titration (iii) Titrant (iv) Titrand (v) End point (vi) Equivalence point (vii) Titration error

Solution**(i) Indicator:**

Indicator is a chemical substance which indicates the end point or neutral point of the reaction between two solutions by changing its colour with the change of the pH of a solution near the equivalent point.

(ii) Titration:

Titration is a volumetric analytical method used to determine the concentration of an unknown solution by reacting it with a standard solution of known concentration until the equivalence point is reached.

(iii) Titrant:

The compound which is taken in the titration burette is called titrant. Mostly its concentration is known.

(iv) Titrand:

The substance which is being analyzed in the titration is called titrand. Mostly its concentration is exactly unknown.

(v) End Point:

The point in a titration at which the reaction between two solutions is complete as shown by indicator is called end point. It must be in acid base solution.

(vi) Equivalence Point:

The point in which one gram equivalent of a substance completely reacts with one gram equivalent of another substance is called equivalence point. It may or may not be in acid base solution.

(vii) Titration Error:

The difference between endpoint and the equivalence point of a titration is called titration error. It can be minimized by (a) using blank titration (b) using standard substance (c) calibrating all the instruments.

15. Write short note on: "Selection of suitable indicators in acid-base titration".

Solution

An indicator is a substance that changes colour at a particular pH range.

Principle:

The indicator should be selected in such a way that:

- Its colour change (transition range) coincides with the equivalence point of the titration.
- The end point should be sharp and easily detectable.

General rules for selecting indicator:

Type of Titration	Suitable Indicator
Strong acid vs Strong base	Phenolphthalein or Methyl orange
Strong acid vs Weak base	Methyl orange
Weak acid vs Strong base	Phenolphthalein
Weak acid vs Weak base	No suitable indicator

16. How would you select suitable indicator in titration between

- a. Na_2CO_3 and HCl
- b. NaOH and H_2SO_4
- c. KMnO_4 and oxalic acid

Solution**(a) Na_2CO_3 and HCl**

Na_2CO_3 = Weak base

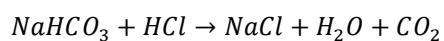
HCl = Strong acid

There are two end points because Na_2CO_3 reacts in two steps.

First step:



Second step:



Suitable indicators:

For first end point → Phenolphthalein

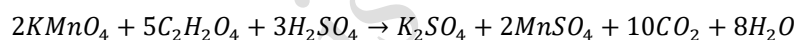
For second end point → Methyl orange

Therefore, methyl orange is generally preferred for complete neutralization.

17. Define redox titration with suitable example.**Solution**

Redox titration: A titration which involves the oxidation and reduction reaction is called redox titration.

Example:

**Numericals:**

1. If 20 mL of $\frac{N}{2}$ HCl , 60 mL of $\frac{N}{10}$ HNO_3 and 150 mL of $\frac{N}{5}$ H_2SO_4 are mixed together, what will be the normality of the resulting acid mixture?

Solution

Volume and normality of the given acids:

$$V_1 = 20 \text{ mL} \qquad N_1 = \frac{N}{2} = 0.5 \text{ N} (\text{HCl})$$

$$V_2 = 60 \text{ mL} \qquad N_2 = \frac{N}{10} = 0.1 \text{ N} (\text{HNO}_3)$$

$$V_3 = 150 \text{ mL} \qquad N_3 = \frac{N}{5} = 0.2 \text{ N} (\text{H}_2\text{SO}_4)$$

Total volume of the mixture:

$$V_T = V_1 + V_2 + V_3 = 20 + 60 + 150 = 230 \text{ mL}$$

Let, the normality of the resulting solution be N_T .

Using the relation for mixing solutions:

$$N_T V_T = N_1 V_1 + N_2 V_2 + N_3 V_3$$

$$\text{Or, } N_T \times 230 = (0.5 \times 20) + (0.1 \times 60) + (0.2 \times 150)$$

$$\text{Or, } N_T \times 230 = 10 + 6 + 30 = 46$$

$$\text{Or, } N_T = \frac{46}{230} = 0.2 \text{ N}$$

Hence, the normality of the final acid mixture is 0.2 N.

- 2. Calculate the molality of a salt (molar mass = 138 g/mol) solution obtained by dissolving 2.5 g of salt in one litre of its solution. Given that density of the solution is 0.85 g cm^{-3} .**

Solution

Given,

$$\text{Mass of salt} = 2.5 \text{ g}$$

$$\text{Molar mass of salt} = 138 \text{ g mol}^{-1}$$

$$\text{Volume of solution} = 1 \text{ L} = 1000 \text{ mL}$$

$$\text{Density of solution} = 0.85 \text{ g cm}^{-3}$$

First, calculate the number of moles of the salt:

$$\text{Moles of salt} = \frac{\text{Mass}}{\text{Molar mass}} = \frac{2.5}{138} \approx 0.018$$

Now, the mass of solution = Volume \times Density

$$= 1000 \times 0.85 = 850 \text{ g}$$

Now, mass of solvent (water) = Mass of solution – Mass of solute

$$= 850 - 2.5 = 847.5 \text{ g}$$

Now, using the formula for molality,

$$\text{Molality} = \frac{\text{Moles of solute}}{\text{Mass of solvent in g}} \times 1000$$

$$\text{Or, } m = \frac{0.018}{847.5} \times 1000 \approx 0.021$$

Hence, the molality of the solution is 0.021 m.

- 3. 100 mL of Na_2CO_3 solution contains 0.53 g of Na_2CO_3 . If 10 mL of this solution is added to 'x' mL of water to obtain 0.01 M Na_2CO_3 solution, calculate the value of x.**

Solution

Given,

$$\text{Volume of } \text{Na}_2\text{CO}_3 \text{ solution (V)} = 100 \text{ mL}$$

$$\text{Weight of } \text{Na}_2\text{CO}_3 \text{ (w)} = 0.53 \text{ g}$$

$$\text{Molar mass} = 106$$

$$\text{So, Equivalent weight of } \text{Na}_2\text{CO}_3 \text{ (E)} = \frac{106}{2} = 53$$

We know that,

$$\text{Normality (N)} = \frac{w \times 1000}{E \times V_{\text{ml}}} = \frac{0.53 \times 1000}{53 \times 100} = 0.1 \text{ N } \text{Na}_2\text{CO}_3$$

First, calculate the normality of the original solution:

$$N_1 = \frac{w \times 1000}{E \times V}$$

$$\text{Or, } N_1 = \frac{0.53 \times 1000}{53 \times 100} = 0.1 \text{ N}$$

Initial

Final

$$V_1 = 10 \text{ mL}$$

$$V_2 = ?$$

$$N_1 = 0.1 \text{ N}$$

$$N_2 = 0.01 \text{ M} = 0.02 \text{ N}$$

$$\text{Now, } V_1 N_1 = V_2 N_2$$

$$\text{Or, } V_2 = \frac{V_1 N_1}{N_2} = \frac{10 \times 0.1}{0.02} = 50 \text{ mL}$$

The volume of water added (x) = 50 – 10 = 40 mL

This is SAMPLE File