

1. VOLUMETRIC ANALYSIS- SUBJECTIVE QUESTIONS

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Gravimetric and volumetric analysis

Equivalent weight

1. Equivalent weight of an element:

1. Provide a short definition of equivalent weight. 1
What do you mean by the equivalent weight of an element? 2
2. Find the equivalent weights of Copper in CuO and Cu₂O. 2
3. A **divalent** metal has an atomic weight of 24. What is its equivalent weight? 2
4. Calculate the equivalent weights of the underlined elements: 4
 - i) Fe₂O₃
 - ii) MgCl₂
 - iii) CH₄
 - iv) NH₃
 - v) CCl₄
 - vi) FeO
 - vii) MgO
 - viii) AlCl₃

2. Equivalent weight of compounds:

Equivalent weight of acid:

5. What is meant by the term basicity? Predict the basicity of H₂SO₄ in the following reaction. 1
 $\text{NaOH} + \text{H}_2\text{SO}_4 \rightarrow \text{NaHSO}_4 + \text{H}_2\text{O}$
6. Can the equivalent weight of H₂SO₄ always be taken as 49? Explain.
7. Find the equivalent weight of H₃PO₄ in the reaction: 1
 $\text{Ca}(\text{OH})_2 + \text{H}_3\text{PO}_4 \rightarrow \text{CaHPO}_4 + 2 \text{H}_2\text{O}$

Equivalent weight of base

8. Define the acidity of a base, and give an example. 2

Equivalent weight of salt:

9. Find the equivalent weight for calcium phosphate. 1

Equivalent weight of oxidising and reducing agents:

Number of gram equivalents:

10. Define the term gram equivalent weight. 1

Concentrations

a. Gram per litre

11. Define the term gram per litre. 1

b. Normality

12. What is Normality? 1
13. Define normal solution. 1
14. Define the terms seminormal solution & decinormal solution. 1

Normality Factor (f):

15. Define the term normality factor. 1
16. What is the importance of calculating the normality factor of solutions during titration? 2
17. Distinguish between Normality and normality factor. 1

a. Molarity

18. Define Molarity. 2
19. Differentiate/Distinguish between Normality and Molarity. 2

Relation between Normality and Molarity

20. Establish the relationship between Molarity and Normality. 2
- How is Normality related to Molarity? 1
- Define Normality and Molarity for a solution. Find their relationship for a given solution. 2
21. Distinguish between decinormal and decimolar solutions. 2
22. Which one has a higher concentration and why?
- a) 80 g/liter NaOH solution and 3 M NaOH solution.
- b) 5.3 g/liter Na_2CO_3 and N/10 Na_2CO_3 solution.
- c) 100 g/L H_2SO_4 and 3M H_2SO_4
23. How would you convert 500 cc of 2 M H_2SO_4 into i) Gram/ litre ii) normality? 2
24. Convert the following:
- i) 2.5 M H_3PO_4 into Normality ii) 4.9 M H_2SO_4 into gram/litre. 2
25. What is the Normality of 20cc of 2 M phosphoric acid (H_3PO_4)? 2
26. A 1 M H_2SO_4 solution is not necessarily a 1 N solution. Explain.

b. Percentage

27. Which one has a higher concentration and why?
- 6.07% NaOH and 6N NaOH solution
28. Calculate the Normality and Molarity of 5 % (w/v) of NaOH solution. (ans =1.25)
29. A solution of conc. HCl contains 38 % HCl by mass; what is the Molarity of this solution if the density of the solution is 1.19g/cc? (ans =12.389M) 2

Molality

30. Define the molality of a solution. 1
31. It is better to express concentration in molality rather than Molarity. Why? 1

c. Formality

d. Ppm (parts per million)

e. ppb (parts per billion)

Primary & secondary standard Substances & solutions

32. Define the term standard solution. 1
- Define the primary standard solution. 1
33. What are the requisites for a substance to be a primary standard? 2
34. Why are the crystals of oxalic acid regarded as a good substance for the preparation of a primary standard solution? 2
35. Is Na_2CO_3 a primary standard solution? Why? 2
36. Define a secondary standard solution with a suitable example. 2
- Define the term secondary standard solution. 1
- What are primary and secondary standard solutions? 2
37. Differentiate between primary and secondary standard solutions. 2
38. Are all standard solutions primary standard solutions or not? 1
- Not all standard solutions are primary standard solutions. Comment on the statement. 1

Law of equivalence and Normality equation

39. Deduce the normality equation. [2]
40. Deduce the normality equation $S_1V_1 = S_2V_2$. Why is the equation not always used to calculate Molarity?
41. Why is normality particularly convenient in titration calculations?

Titration

42. What is meant by redox titration? Write an example of it. 2
Write an example of redox titration. Why is it called so? 2
43. What is meant by acidimetry? 1
44. Define alkalimetry. 1
45. Crystals of oxalic acid are generally used to prepare a primary standard solution.
i) Define the primary standard solution.
ii) Which chemical indicator is used to titrate KMnO_4 solution versus oxalic acid solution?
iii) Why is the oxalic acid solution warmed, adding dilute H_2SO_4 before titrating with KMnO_4 ? 1+1+1+1
iv) Mention a major application of titration in the quality control laboratory. 1+1+1+1
Give reason: Oxalic acid solution is warmed by adding dil. H_2SO_4 before titration with KMnO_4 . [1]

Endpoint, Equivalence point, and Neutral point

46. Define the terms i) equivalence point of a reaction, ii) endpoint of a titration 2
Define the term endpoint. 2
Define the term equivalence point. 1
47. Distinguish between the endpoint and the equivalence point of a reaction. 2
48. Define titration error. 1
49. Distinguish between titration error and normality factor. 2
50. Distinguish between titrant and titrand. 2
51. During titration, the concentration of KMnO_4 solution can be determined by using a standard oxalic acid solution.
i. What is meant by a standard solution?
ii. Calculate the equivalent weight of KMnO_4 in an acidic medium. (Molar mass of $\text{KMnO}_4 = 158$)
(ans = 31.6)
iii. Why is the above titration called a redox titration?
iv. Name the indicator used in this titration. 1+1+1+1

Dilution Numericals

52. What volume of water must be added to 40ml of 0.25N acid solution to make it exactly decinormal? (ans = 60ml)
53. What volume of water should be added to 50 ml of semi-normal NaOH solution to make it exactly decinormal? (ans = 200 ml) 2
54. What volume of water should be added to 500 mL of 2N ($f = 0.98$) Na_2CO_3 to make it exactly N/10? (ans = 9300ml) 2
55. X cc of 5 N HCl was diluted to one litre of normal solution. Calculate the value of X. (ans = 200ml) 2
56. Your chemistry teacher added 4 g of sodium hydroxide to a bottle containing 20 cc of 2 N H_2SO_4 , and he diluted it up to 1 litre by adding water. Then he gave you blue and red litmus paper.
a. Which litmus paper would you use to test the solution and why?
b. Calculate the Normality of the resulting solution.

Titration (Neutralisation)

57. X g of magnesium (equivalent weight=12) reacts with 20 ml of N ($f = 0.95$) acid. Calculate the weight of X. (ans = 0.228g) 2
(Hint: gram equivalents of Mg = gram equivalents of acid
Normality = number of gram equivalents/ volume in litres)
58. How many moles of H_2SO_4 are required to neutralise 4 litres of 2N NaOH solution? (ans = 4 moles) 2
59. What mass of 90% pure CaCO_3 is required to neutralise 2 litres of a decinormal solution of HCl? (ans = 11.11 g) 2
60. X g of CaCO_3 reacts completely with 20 mL of 1 M HCl solution. Calculate the value of X. (ans = 1 g) 2
61. 5 g of a dibasic acid is completely neutralised by 50 mL of 2N NaOH. Find the molecular weight of the acid. (ans = 100 amu) 2
62. 20 mL of Sulfuric acid solution neutralises 0.265 g of Na_2CO_3 . Calculate the Normality of the acid solution. (ans = 0.25 N) 2
63. What volume of 5% NaOH is required to neutralise 2 litres of decinormal H_2SO_4 ? (ans = 0.16 l) 2
64. 0.715 g of $\text{Na}_2\text{CO}_3 \cdot x\text{H}_2\text{O}$ required 20 mL of a semi-normal hydrochloric acid solution for a complete reaction. Find the value of x. (ans = 2) 3
65. 1 g of NaOH is added to 2 litres of x M H_2SO_4 solution so that the pH of the resulting solution is 7. Find the value of x. (ans = 0.00625) 2
66. 0.315 g of a dibasic acid required 50 mL of decinormal sodium hydroxide solution for complete neutralisation. Find the molecular mass of the acid. (ans = 126 amu) 2
67. What volume of a decinormal solution of HCl is required to neutralise 25 mL of NaOH solution containing 8 g NaOH in a one-litre solution? 2
68. A chemistry lab boy weighed 1.31 g of Na_2CO_3 to prepare 250 mL of its decinormal solution.
i) Find the volume of water required to be evaporated to make it an exactly normal solution. 2
ii) Calculate the mass of oxalic acid crystals required to neutralise the solution properly. 2
69. You are provided with three acids and three bases with their respective concentrations as shown below. If the same volume is used, find out which acid exactly neutralises which base among these. 2
- | | | |
|-------------------------------------|-------------------------------------|-------------------------------------|
| H_3PO_4 [0.1 M] | HNO_3 [0.15 N] | NaOH [1.6 grams in 100 mL solution] |
| Na_2CO_3 [10.6 g/L] | $\text{Ca}(\text{OH})_2$ [11.1 g/L] | H_2SO_4 [0.18 M] |
70. Calculate the volume of 1 M NaOH required to neutralise 200 cc of 2 M HCl. What mass of sodium chloride is produced from the neutralisation reaction? (ans = 400 ml, 23.4 g) 3
71. What volumes of 12 M NaOH and 2 M NaOH should be mixed to get 2 litres of 9 M NaOH solution? (ans = 1.4 & 0.6 l) 3
72. Calculate the resulting Normality of a solution prepared by mixing 20 mL of 0.8 M NaOH with 25 mL of 0.4 M H_2SO_4 solution. (ans = 0.0889 N) 3
73. 500 cc of 2N Na_2CO_3 are mixed with 400 cc of 3N H_2SO_4 solution and volume was diluted to one liter. Will the resulting solution be acidic, basic, or neutral? Also, calculate the Molarity of the diluted solution. (ans = acidic, 0.1 M) 2+2
74. 10 g of NaOH was added to 200 cc of N/2($f=1.5$) H_2SO_4 solution. The volume was diluted to two litres. Predict whether the dilute solution is acidic, basic, or neutral, and calculate the resulting Molarity of the dilute solution. (ans = basic, 0.05 M) 2+2
75. If 20 mL of 0.5 N NaOH solution is mixed with 30 mL of 0.3 N HCl, is the resulting solution acidic or basic? Calculate the Normality with respect to the acidic or basic final solution. (0.02 N) 2
76. A sample of Na_2CO_3 weighing 0.53 g is added to 101 mL of 0.1 M H_2SO_4 solution. Will the resulting solution be acidic, basic, or neutral? 2

77. 1 g of a divalent metal was dissolved in 25 mL of 1 M H_2SO_4 . The unreacted acid required an additional 15 cc of NaOH ($f = 0.8$) for complete neutralisation.
- Calculate the gram equivalent of unreacted acid. (ans = 0.012)
 - Find the atomic weight of the metal. (ans = 52.63 amu) 3
78. Experimental data obtained by titrating a decinormal solution of Na_2CO_3 with an unknown strength of H_2SO_4 solution are given below.

Expt.	Volume of Na_2CO_3 (mL)	Volume of H_2SO_4 (mL)	
		Initial	final
I	25	0.00	20.50
II	25	0.00	20.00
III	25	0.00	20.00

- Name the above titration. [1]
 - Which indicator is used in the above titration and why? [1+1]
 - Calculate the normality of H_2SO_4 from the above data. [2]
79. 3.15 g of oxalic acid crystals ($\text{C}_2\text{H}_2\text{O}_4 \cdot 2\text{H}_2\text{O}$) were dissolved in water to prepare 500 mL of solution.
- Determine the normality of the acid. (ans = 0.1N) [1]
 - The acid solution became permanently pink when 400 mL of KMnO_4 solution (eq. wt. = 31.5) was added during titration. What mass of KMnO_4 is present in 1 litre of the solution? (ans = 3.938 g) [2]
80. A standard Na_2CO_3 solution is used to determine the strength of H_2SO_4 during titration.
- How is the completion of the reaction in this titration detected? Is the solution prepared from the Na_2CO_3 a primary standard? Why? 2
 - 2.16 g of pure Na_2CO_3 is added to 400 mL of a decinormal H_2SO_4 solution. How many grams of H_2SO_4 are further required to neutralise the resultant solution completely? (ans = 0.03698 g) 3

Higher Ability Question (for advanced learners)

81. Concentrated nitric acid is used as a laboratory reagent and usually contains 69% by mass of nitric acid. The density of the nitric acid is 1.41 g cm^{-3} . Calculate the volume and normality of the solution containing 23 g of nitric acid. (ans = 15.45 N) 4
82. Calculate the molality of one litre of 93% H_2SO_4 solution (weight by volume). The density of the solution is 1.84 g/mL . (ans = 10.43) 4
83. An aqueous solution of a dibasic acid containing 17.7 g of acid per litre of solution has a density of 1.0077 g mL^{-1} (molar mass of the acid = 118 g mol^{-1}). Calculate (i) molarity (ans = 0.15) and (ii) molality. (Ans = 0.1515) 2+2
84. What volume of 95% Sulfuric acid (density = 1.85 g/cc) and mass of water must be taken to prepare 100cc of 15% solution of Sulfuric acid (density = 1.1 g/cc)? (ans = 9.39cc and 90.61g) 4
85. How many mL of conc. HNO_3 of specific gravity 1.41 containing 69% by mass is required to prepare 500 mL of 0.5 N HNO_3 . (ans = 16.191 ml) 4
86. A solution of conc. HCl contains 38% HCl by mass. What volume of conc. HCl are required to neutralise one litre of 0.1 M NaOH solution? (Ans = 0.96 l) 2
87. 0.012 g of a divalent metal is completely dissolved in 40cc of N/10 HCl. The excess acid required 15 cc of N/5 NaOH for neutralisation. Find the atomic weight of the metal. (ans = 24 amu) 4
88. 3.33 grams of a trivalent metal were dissolved in 100 mL of 2 M H_2SO_4 ($f = 1.02$). The excess acid required 20 mL of 2 M NaOH ($f = 0.97$) for complete neutralisation. Find the atomic weight of the metal. (27.06 amu) 3

89. 0.8 g of a divalent metal was dissolved in 100 cc of 1.28 N HCl, and the solution was diluted to 200 cc. Then 50 cc of this solution required 54.6 cc of 0.22 N NaOH for neutralisation. Find the atomic weight of the metal. (ans = 20 D) 5
90. 0.4 g of a divalent metal was dissolved in 50cc of 0.64 N HCl, and the solution was diluted to 100 cc. Then 25 cc of this solution required 25.3 cc of 0.11 N NaOH for neutralisation. Find the atomic mass of the metal. (ans = 38.33) 4
91. 4 g of a divalent metal was dissolved in 100 cc of 2 M H_2SO_4 ($f = 1.01$). The excess acid required 30 cc of 1 N NaOH for complete neutralisation. Find the atomic weight of the metal. (ans = 21.4) 4
92. 25 cc of an alkali solution is mixed with 8 cc of 0.75 N acid solution for complete neutralisation; it further requires 15cc of 0.8 N acid solution. Find the strength of the given alkali solution. (ans = 0.72 N) 2
93. A commercial sample of Sulfuric acid has a specific gravity of 1.8. 10 mL of this acid was diluted to 1 litre with water. 10 mL of the diluted solution required 30 mL of N/10 NaOH for complete neutralisation. Calculate the percentage purity of H_2SO_4 in the commercial sample. (ans = 81.67%) 3
94. How many moles of 0.1 M HCl are required to react completely with a 1 g mixture of NaHCO_3 and Na_2CO_3 containing the equimolar amount of the two? (ans = 0.01578 moles) 4
95. x g of a metal (eqv. wt. = 12) was completely dissolved in 100 cc of N/2 HCl. The volume was then made up to 500 cc. 25 cc of this diluted acid required 17.5 cc N/10 NaOH for complete neutralisation. Find the value of x. (ans = 0.18 g) 5
96. 7.35 g of a dibasic acid was dissolved in water and diluted to 250 ml. 25 ml of this solution was neutralised by 15 ml of 1N NaOH solution. What are the equivalent weight and molecular weight of the acid? 5
97. 7.5g of a dibasic acid was dissolved in water, and the solution was made up to 250 cc. 25 cc of this acid requires 16.3cc (1N) NaOH for complete neutralisation. Calculate the molecular weight of the acid. (ans = 92 amu) 4
98. 12 g of commercial zinc is made to react with excess dilute H_2SO_4 . The total volume of H_2 gas liberated was 4.2 litres at 570 mmHg and 279 K. Determine the percentage purity of the zinc. [Atomic mass of Zn = 65] (ans = 74.48%) 4
99. 1 g of a divalent metal was dissolved in 25 mL of 2N H_2SO_4 ($f = 1.01$). The excess acid required 15.1 mL of 1N NaOH ($f = 0.8$) for complete neutralisation. Find the atomic weight of the metal. (ans = 52.05 a.m.u.)
100. 0.70 g of a sample of $\text{Na}_2\text{CO}_3 \cdot x\text{H}_2\text{O}$ was dissolved in water, and the volume was made up to 100 mL. 20 mL of this solution required 19.8 mL of N/10 HCl for complete neutralisation. Find the value of x. [4]

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