

Acid-Base Chemistry

1. What happens when scientists find a theory, such as Arrhenius' Theory of acids, to be unacceptable?
2. State two main ways in which a theory or a theoretical definition may be tested.
3. In terms of modern evidence, what is the nature of a hydrogen ion in aqueous solution?
4. Aqueous solutions of nitric acid and nitrous acid of the same concentration are prepared.
 - a) How do their pH values compare?
 - b) Explain your answer using equations.
5. State two examples of conjugate acid-base pairs, each involving the hydrogen sulfite ion.
6. If the pH of a solution is 6.8, what is the colour of each of the following indicators in this solution?
 - a) methyl red
 - b) chlorophenol red
 - c) bromothymol blue
 - d) phenolphthalein
 - e) methyl orange
7. pH curves provide information about acid-base reaction systems.
 - a) What is a buffering action?
 - b) Where does buffering action appear on a pH curve?
 - c) How are quantitative reactions represented on a pH curve?
 - d) Define pH endpoint and equivalence point.
 - e) How is a suitable indicator chosen for a titration?
 - f) Do non-quantitative reactions have an endpoint? Explain your answer briefly.
8. Predict, where possible, whether each of the following chemical solutions will be acidic, basic, or neutral. If necessary, communicate two balanced chemical equations, one for the possible formation of hydronium ions and one for the possible formation of hydroxide ions.
 - a) aqueous hydrogen bromide
 - b) aqueous potassium nitrite
 - c) aqueous ammonia
 - d) aqueous sodium hydrogen sulfate
9. Write an experimental design to test the predictions in question seven.
10. Write two experimental designs to rank a group of bases in order of strength.
11. Compounds may be classified as ionic or molecular. Each of these classes can be subdivided into neutral substances, acids, or bases. Construct a flow chart that includes two examples for each of the six categories under the headings "Ionic" and "Molecular".
12. Separate samples of an unknown solution were tested with indicators. Congo red was red and chlorophenol red was yellow in the solution. Estimate the approximate pH and hydronium ion concentration of the solution.
13. One way to evaluate a theory is to test predictions with new substances. Sodium methoxide, $\text{NaCH}_3\text{O}(\text{s})$, is dissolved in water. Will the final solution be acidic, basic, or neutral? Explain your answer using equations.
14. In an experimental investigation of amphiprotic substances, samples of baking soda were added to a solution of sodium hydroxide and to a solution of hydrochloric acid. The pH of the sodium hydroxide changed from 13.0 to 9.5 after the addition of the baking soda. The pH of the hydrochloric acid changed from 1.0 to 4.5 after the addition of baking soda. Provide a theoretical explanation of these results by writing chemical equations to describe the reactions.
15. Each of seven unlabelled beakers was known to contain one of the following 0.10 mol/L solutions: $\text{CH}_3\text{COOH}(\text{aq})$, $\text{Ba}(\text{OH})_2(\text{aq})$, $\text{NH}_3(\text{aq})$, $\text{C}_2\text{H}_4(\text{OH})_2(\text{aq})$, $\text{H}_2\text{SO}_4(\text{aq})$, and $\text{NaOH}(\text{aq})$. Describe diagnostic test(s) required to distinguish the solutions and label the beakers. Use the "If _____, and _____, then _____" format, a flow chart, or a table to communicate your answer.

Acid-Base Chemistry – Continued

16. A pH meter was used to determine the endpoint of a titration of 10.00 mL samples of hypochlorous acid with 0.350 mol/L barium hydroxide solution. At the endpoint, a stoichiometrically equivalent volume of 12.6 mL of hydroxide solution was required. What is the molar concentration of the hypochlorous acid solution?
17. A 25.0 mL sample of diluted rust-removing solution containing phosphoric acid was titrated to the second endpoint using 1.50 mol/L sodium hydroxide. The average equivalence point of the sodium hydroxide solution was 17.9 mL. What is the concentration of phosphoric acid in the rust-removing solution?
18. A 50.0 mL volume of 0.560 mol/L hydrochloric acid was spilled on a counter. A student quickly decided to sprinkle calcium hydroxide onto the spill. If 1.00 g of solid calcium hydroxide was used, would it completely neutralize the acid? Justify your answer with calculations.
19. Critique the following experimental designs.
 - a) Sodium hydroxide is titrated against a phosphoric acid solution to the third equivalence point using the bromothymol blue colour change as the endpoint.
 - b) The concentration of hydroxide ions in an ammonia solution is determined by precipitating the ions with silver nitrate solution.
 - c) Hydrochloric acid is used as a primary standard to determine the concentration of sodium sulfide solution.
 - d) Litmus is used as a diagnostic test of the reaction between sodium hydrogen carbonate and sodium hydroxide.
20. At 25°C, the hydrogen ion concentration in vinegar is 1.3 mmol/L. Calculate the hydroxide ion concentration.
21. Acid rain has a pH less than that of normal rain. The presence of dissolved carbon dioxide, which forms carbonic acid, gives normal rain a pH of 5.6. What is the hydrogen ion concentration in normal rain?
22. If the pH of a solution changes by 3 pH units as a result of adding a weak acid, by how much does the hydrogen ion concentration change?
23. Write an experimental design for the identification of four colourless solutions: a strong acid solution, a weak acid solution, a neutral molecular solution, and a neutral ionic solution. Write sentences, create a flow chart, or design a table to describe the required diagnostic tests.
24. Salicylic acid, $C_6H_4OHCOOH$, is an active ingredient of solutions, such as Clearasil®, that are used to treat acne. Since the K_a for this acid was not listed in any convenient references, a student tried to determine the value experimentally. If the pH of a saturated (1.00 g/460.0 mL) solution of salicylic acid was found to be 2.4 at 25°C, calculate the ionization constant for this acid.
25. A 0.10 mol/L solution of lactic acid, found in sour milk, has a pH of 2.43. Calculate the percent ionization of lactic acid in water.
26. Ascorbic acid is the chemical ingredient of Vitamin C. A student prepares a 0.20 mol/L aqueous solution of ascorbic acid, measures its pH, and finds it to be 2.40. Based on this evidence, what is the K_a for ascorbic acid?
27. The hydroxide ion concentration in a 0.157 mol/L solution of sodium propanoate, $NaC_2H_5COO(aq)$, is found to be 1.1×10^{-5} mol/L. Calculate the base ionization constant for the propanoate ion.
28. Aniline, $C_6H_5NH_2$, is closely related to ammonia and is also a weak base. If the pH of a 0.10 mol/L aniline solution was found to be 8.81, what is its K_b ?
29. Codeine has a K_b of 1.73×10^{-6} . Calculate the pH of a 0.020 mol/L codeine solution.