CHEMISTRY

ACID - BASE REACTIONS

Acids and bases are considered to be opposites. As such, when an acid and a base are reacted together they cancel each other out. This is called a ***Neutralization Reaction***.

The reaction between an acid and a base produces ***water*** and an ***ionic compound*** (*a salt*).

Acid + Base → Water + a Salt

Ex:

$$HNO_{3(aq)} + NaOH_{(aq)} \rightarrow H_2O_{(l)} + NaNO_{3(aq)}$$

In order to have the reaction completely neutralize, the molar ratio must be followed. If there is excess acid, then the excess will not get neutralized and will be present in the products.

$$2\ HNO_{3(aq)} + NaOH_{(aq)} \rightarrow H_2O_{(l)} + NaNO_{3(aq)} + 1\ HNO_{3(aq)}$$

Most of the stoichiometry involving acids and bases requires a person tc calculate the quantities required to complete a neutralization reaction.

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Ex: *13.84 mL of hydrochloric acid just neutralizes 25.00 mL of a 0.10 M solution of sodium hydroxide. What is the concentration of the hydrochloric acid?*

Ex: *What volume of 0.25 M sulfuric acid is needed to react completely with 37.2 mL of 0.65 M potassium hydroxide?*

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Ex: Mr. Caslick accidentally spills 500mL of 18M sulphuric acid on the floor of the lab. In an effort to neutralize the spill, he mixes up a solution of 1M sodium hydroxide. He then pours 1 L of the sodium hydroxide onto the spill? Does he successfully neutralize the acid? What is the pH of the resulting solution?

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ACID-BASE NEUTRALIZATION - Practice

10. 17.85 mL of nitric acid neutralizes 25.00 mL of 0.150 mol/L $NaOH_{(aq)}$. What is the concentration of the nitric acid?

11. What volume of 1.015 mol/L magnesium hydroxide is needed to neutralize 40.0 mL of 1.60 mol/L hydrochloric acid?

12. What volume of 0.150 mol/L hydrochloric acid is needed to neutralize each solution below?
    (a) 25.0 mL of 0.135 mol/L sodium hydroxide
    (b) 20.0 mL of 0.185 mol/L ammonia solution
    (c) 80 mL of 0.0045 mol/L calcium hydroxide

13. What concentration of sodium hydroxide solution is needed for each neutralization reaction?
    (a) 37.82 mL of sodium hydroxide neutralizes 15.00 mL of 0.250 mol/L hydrofluoric acid.
    (b) 21.56 mL of sodium hydroxide neutralizes 20.00 mL of 0.145 mol/L sulfuric acid.
    (c) 14.27 mL of sodium hydroxide neutralizes 25.00 mL of 0.105 mol/L phosphoric acid.

14. 80.0 mL of 4.00 mol/L, H_2SO_4 are diluted to 400.0 mL by adding water. What is the molar concentration of the sulfuric acid after dilution?

15. In a titration experiment, 25.0 mL of an aqueous solution of sodium hydroxide was required to neutralize 50.0 mL of 0.010 mol/L hydrochloric acid. What is the molar concentration of the sodium hydroxide solution?

4 I A 25.0 mL sample of sulfuric acid is completely neutralized by adding 32.8 mL of 0.116 mol/L ammonia solution. Ammonium sulfate, $(NH_4)_2SO_4$, and water are formed. What is the concentration of the sulfuric acid?

5 I The following data were collected during a titration. Calculate the concentration of the sodium hydroxide solution.

Titration Data

Volume of $HCl_{(aq)}$	10.00 mL
Final volume of $NaOH_{(aq)}$	23.08 mL
Initial volume of $NaOH_{(aq)}$	1.06 mL
Concentration of $HCl_{(aq)}$	0.235 mol/L

Answers 10. 0.210 mol/L 11. 31.5 mL 12.(a) 22.5 mL (b) 24.7 mL (c) 4.8 mL 13.(a) 0.0992 mol/L (b) 0.269 mol/L (c) 0.552 mol/L 14. 0.800 mol/L 15. 0.020 mol/L 4. 0.304 mol/L 5. 0.107 mol/L

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Practice Problems

1. Hydrochloric acid was slowly added to an Erlenmeyer flask that contained 50.0 mL of 1.50 mol/L sodium hydroxide, NaOH(aq), and a pH meter. The pH meter read 7.0 after the addition of 35.3 mL of hydrochloric acid. Calculate the concentration of the hydrochloric acid.
2. What volume of 0.400 mol/L sodium hydroxide, NaOH(aq), is needed to neutralize 26.8 mL of 0.504 mol/L sulfuric acid, $H_2SO_4(aq)$, completely? **Hint:** Sulfuric acid loses two hydrogen ions during this neutralization reaction.
3. A 25.00 mL sample of a nitric acid solution, $HNO_3(aq)$, is neutralized by 18.55 mL of a 0.1750 mol/L sodium hydroxide, NaOH(aq). What is the concentration of the nitric acid solution?
4. What volume of 1.25 mol/L hydrobromic acid, HBr(aq), will neutralize 75.0 mL of 0.895 mol/L magnesium hydroxide, $Mg(OH)_2(aq)$?
5. A solution of sodium hydroxide was prepared by dissolving 4.0 g of sodium hydroxide, NaOH(s), in 250 mL of water. It was found that 20.0 mL of the sodium hydroxide solution neutralizes 25.0 mL of vinegar. Determine the concentration of acetic acid, $CH_3COOH(aq)$, in the sample of vinegar. Assume that acetic acid is the only acidic substance in the vinegar.
6. Phosphoric acid, $H_3PO_4(aq)$, is a triprotic acid. If 15.0 mL of phosphoric acid completely neutralizes 38.5 mL of 0.150 mol/L sodium hydroxide, NaOH(aq), what is the concentration of the phosphoric acid?
7. The acidity of a water sample can be measured by a neutralization reaction with a solution of sodium hydroxide, NaOH(aq). What is the concentration of hydrogen ions in a water sample if 100 mL of the sample is neutralized by the addition of 8.0 mL of 2.5×10^{-3} mol/L sodium hydroxide?
8. Citric acid, $H_3C_6H_5O_7(aq)$, is a weak, triprotic acid that occurs naturally in many fruits and vegetables, especially the citrus fruits from which it gets its name. What volume of 0.165 mol/L sodium hydroxide, NaOH(aq), will completely react with 40.0 mL of 0.120 mol/L citric acid? For this calculation, assume that all the hydrogen ions are released by the citric acid.
9. Phosphoric acid, $H_3PO_4(aq)$, is a weak, triprotic acid. When phosphoric acid reacts with a base, different salts can be prepared, depending on how many hydrogen ions are replaced by cations. For example, potassium hydrogen phosphate, $K_2HPO_4(aq)$, can be prepared in an aqueous solution by adding just enough potassium hydroxide, KOH(aq), to replace two hydrogen ions: $H_3PO_4(aq) + 2KOH(aq) \rightarrow K_2HPO_4(aq) + 2H_2O(\ell)$ What volume of 0.185 mol/L potassium hydroxide should be added to 80.0 mL of 0.137 mol/L phosphoric acid to form a solution of potassium hydrogen phosphate?
10. What volume of 0.150 mol/L calcium hydroxide, $Ca(OH)_2(aq)$, is needed to completely neutralize 20 mL of 0.185 mol/L sulfuric acid, $H_2SO_4(aq)$?

Answers to Practice Problem Questions

1. 2.12 mol/L
2. 67.5 mL
3. 0.1298 mol/L
4. 107 mL
5. 0.32 mol/L
6. 0.128 mol/L
7. 2×10^{-4} mol/L
8. 87.3 mL
9. 118 mL
10. 2×10^{1} mL (Rounded to appropriate number of significant digits)