

AP Chemistry: Acids & Bases

Multiple Choice

33. The pH of 0.1-molar ammonia is approximately...

- (A) 1 (B) 4 (C) 7 (D) 11 (E) 14

48. Which of the following ions is the strongest Lewis acid?

- (A) Na^+ (B) Cl^- (C) CH_3COO^- (D) Mg^{2+} (E) Al^{3+}

49. Each of the following can act as both a Brønsted acid and a Brønsted base EXCEPT...

- (A) HCO_3^- (B) H_2PO_4^- (C) NH_4^+ (D) H_2O (E) HS^-

53. Which, if any, of the following species is in the greatest concentration in a 0.100-molar solution of H_2SO_4 in water?

- (A) H_2SO_4 molecules (B) H_3O^+ ions (C) HSO_4^- ions
(D) SO_4^{2-} ions (E) All species are in equilibrium and therefore have the same concentrations.

71. Which of the following reactions does NOT proceed significantly to the right in aqueous solutions?

- (A) $\text{H}_3\text{O}^+ + \text{OH}^- \rightarrow 2 \text{H}_2\text{O}$ (B) $\text{HCN} + \text{OH}^- \rightarrow \text{H}_2\text{O} + \text{CN}^-$
(C) $\text{Cu}(\text{H}_2\text{O})_4^{2+} + 4 \text{NH}_3 \rightarrow \text{Cu}(\text{NH}_3)_4^{2+} + 4 \text{H}_2\text{O}$ (D) $\text{H}_2\text{SO}_4 + \text{H}_2\text{O} \rightarrow \text{H}_3\text{O}^+ + \text{HSO}_4^-$
(E) $\text{H}_2\text{O} + \text{HSO}_4^- \rightarrow \text{H}_2\text{SO}_4 + \text{OH}^-$

75. If the acid dissociation constant, K_a , for an acid HA is 8×10^{-4} at 25°C , what percent of the acid is dissociated in a 0.50-molar solution of HA at 25°C ?

- (A) 0.08% (B) 0.2% (C) 1% (D) 2% (E) 4%

34. All of the following species can function as Brønsted-Lowry bases in solution EXCEPT...

- (A) H_2O (B) NH_3 (C) S^{2-} (D) NH_4^+ (E) HCO_3^-

46. As the number of oxygen atoms increases in any series of oxygen acids, such as HXO , HXO_2 , HXO_3 , ..., which of the following is generally true?

- (A) The acid strength varies unpredictably.
(B) The acid strength decreases only if X is a nonmetal.
(C) The acid strength decreases only if X is a metal.
(D) The acid strength decreases whether X is a nonmetal or a metal.
(E) The acid strength increases.

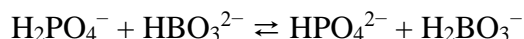
50. Which of the following acids can be oxidized to form a stronger acid?

- (A) H_3PO_4 (B) HNO_3 (C) H_2CO_3 (D) H_3BO_3 (E) H_2SO_3

54. Which of the following is the correct equilibrium expression for the hydrolysis of CO_3^{2-} ?

- (A) $K = [\text{HCO}_3^-] / ([\text{CO}_3^{2-}] [\text{H}_3\text{O}^+])$ (B) $K = ([\text{HCO}_3^-] [\text{OH}^-]) / [\text{CO}_3^{2-}]$
 (C) $K = ([\text{CO}_3^{2-}] [\text{OH}^-]) / [\text{HCO}_3^-]$ (D) $K = [\text{CO}_3^{2-}] / ([\text{CO}_2] [\text{OH}^-]^2)$
 (E) $K = ([\text{CO}_3^{2-}] [\text{H}_3\text{O}^+]) / [\text{HCO}_3^-]$

55. The equilibrium constant for the reaction represented by the equation below is greater than 1.0. Which of the following gives the correct relative strengths of the acids and bases in the reaction?



	Acids		Bases
(A)	$\text{H}_2\text{PO}_4^- > \text{H}_2\text{BO}_3^-$	and	$\text{HBO}_3^{2-} > \text{HPO}_4^{2-}$
(B)	$\text{H}_2\text{BO}_3^- > \text{H}_2\text{PO}_4^-$	and	$\text{HBO}_3^{2-} > \text{HPO}_4^{2-}$
(C)	$\text{H}_2\text{PO}_4^- > \text{H}_2\text{BO}_3^-$	and	$\text{HPO}_4^{2-} > \text{HBO}_3^{2-}$
(D)	$\text{H}_2\text{BO}_3^- > \text{H}_2\text{PO}_4^-$	and	$\text{HPO}_4^{2-} > \text{HBO}_3^{2-}$
(E)	$\text{H}_2\text{PO}_4^- = \text{H}_2\text{BO}_3^-$	and	$\text{HPO}_4^{2-} = \text{HBO}_3^{2-}$

56. A 0.20-molar solution of a weak monoprotic acid, HA, has a pH of 3.00. The ionization constant of this acid is...

- (A) 5.0×10^{-7} (B) 2.0×10^{-7} (C) 5.0×10^{-6} (D) 5.0×10^{-3} (E) 2.0×10^{-3}

22. $\text{HSO}_4^- + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{SO}_4^{2-}$ In the equilibrium represented above, the species that act as bases include which of the following?

I. HSO_4^- II. H_2O III. SO_4^{2-}

- (A) II only (B) III only (C) I and II (D) I and III (E) II and III

31. $\text{H}_2\text{C}_2\text{O}_4 + 2 \text{H}_2\text{O} \rightleftharpoons 2 \text{H}_3\text{O}^+ + \text{C}_2\text{O}_4^{2-}$ Oxalic acid, $\text{H}_2\text{C}_2\text{O}_4$, is a diprotic acid with $K_1 = 5 \times 10^{-2}$ and $K_2 = 5 \times 10^{-5}$. Which of the following is equal to the equilibrium constant for the reaction represented above?

- (A) 5×10^{-2} (B) 5×10^{-5} (C) 2.5×10^{-6} (D) 5×10^{-7} (E) 2.5×10^{-8}

61. A 1-molar solution of which of the following salts has the highest pH?

- (A) NaNO_3 (B) Na_2CO_3 (C) NH_4Cl (D) NaHSO_4 (E) Na_2SO_4

66. What is the pH of a 1.0×10^{-2} -molar solution of HCN? ($K_a = 4.0 \times 10^{-10}$)

- (A) 10 (B) Between 7 and 10 (C) 7 (D) Between 4 and 7 (E) 4

45. What is the $\text{H}^+_{(\text{aq})}$ concentration in 0.05 M $\text{HCN}_{(\text{aq})}$? (The K_a for HCN is 5.0×10^{-10})

- (A) 2.5×10^{-11} (B) 2.5×10^{-10} (C) 5.0×10^{-10} (D) 5.0×10^{-6} (E) 5.0×10^{-4}

38. A molecule or an ion is classified as a Lewis acid if it...

- (A) accepts a proton from water (B) accepts a pair of electrons to form a bond
(C) donates a pair of electrons to form a bond (D) donates a proton to water
(E) has resonance Lewis electron-dot structures

64. The net ionic equation for the reaction that occurs during the titration of nitrous acid with sodium hydroxide is...

- (A) $\text{HNO}_2 + \text{Na}^+ + \text{OH}^- \rightarrow \text{NaNO}_2 + \text{H}_2\text{O}$
(B) $\text{HNO}_2 + \text{NaOH} \rightarrow \text{Na}^+ + \text{NO}_2^- + \text{H}_2\text{O}$
(C) $\text{H}^+ + \text{OH}^- \rightarrow \text{H}_2\text{O}$
(D) $\text{HNO}_2 + \text{H}_2\text{O} \rightarrow \text{NO}_2^- + \text{H}_3\text{O}^+$
(E) $\text{HNO}_2 + \text{OH}^- \rightarrow \text{NO}_2^- + \text{H}_2\text{O}$

16. Commercial vinegar was titrated with NaOH solution to determine the content of acetic acid, $\text{HC}_2\text{H}_3\text{O}_2$. For 20.0 milliliters of the vinegar, 32.0 milliliters of 0.500-molar NaOH solution was required. What was the concentration of acetic acid in the vinegar if no other acid was present?

- (A) 1.60 M (B) 0.800 M (C) 0.640 M (D) 0.600 M (E) 0.400 M

Acid	Acid Dissociation Constant, K_a
H_3PO_4	7×10^{-3}
H_2PO_4^-	8×10^{-8}
HPO_4^{2-}	5×10^{-13}

63. On the basis of the information above, a buffer with a pH = 9 can best be made by using...

- (A) pure NaH_2PO_4 (B) $\text{H}_3\text{PO}_4 + \text{H}_2\text{PO}_4^-$ (C) $\text{H}_2\text{PO}_4^- + \text{PO}_4^{3-}$
(D) $\text{H}_2\text{PO}_4^- + \text{HPO}_4^{2-}$ (E) $\text{HPO}_4^{2-} + \text{PO}_4^{3-}$

19. In the titration of a weak acid of unknown concentration with a standard solution of a strong base, a pH meter was used to follow the progress of the titration. Which of the following is true for this experiment?

- (A) The pH is 7 at the equivalence point.
(B) The pH at the equivalence point depends on the indicator used.
(C) The graph of pH versus volume of base added rises gradually at first and then much more rapidly.
(D) The graph of pH versus volume of base added shows no sharp rise.
(E) The $[\text{H}^+]$ at the equivalence point equals the ionization constant of the acid.

55. What volume of 0.150-molar HCl is required to neutralize 25.0 milliliters of 0.120-molar $\text{Ba}(\text{OH})_2$?

- (A) 20.0 mL (B) 30.0 mL (C) 40.0 mL (D) 60.0 mL (E) 80.0 mL

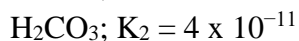
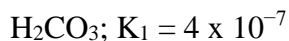
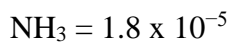
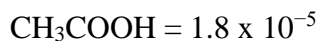
35. When phenolphthalein is used as the indicator in a titration of an HCl solution with a solution of NaOH, the indicator undergoes a color change from clear to red at the end point of the titration. This color change occurs abruptly because...

- (A) phenolphthalein is a very strong acid that is capable of rapid dissociation
- (B) the solution being titrated undergoes a large pH change near the end point of the titration
- (C) phenolphthalein undergoes an irreversible reaction in basic solution
- (D) OH^- acts as a catalyst for the decomposition of phenolphthalein
- (E) phenolphthalein is involved in the rate-determining step of the reaction between H_3O^+ and OH^-

8. Use these answers for questions 8 - 10.

- (A) a solution with a pH less than 7 that is not a buffer solution
- (B) a buffer solution with a pH between 4 and 7
- (C) a buffer solution with a pH between 7 and 10
- (D) a solution with a pH greater than 7 that is not a buffer solution
- (E) a solution with a pH of 7

Ionization Constants



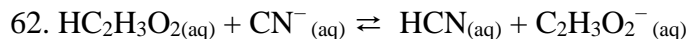
8. A solution prepared to be initially 1 M in NaCl and 1 M in HCl.

9. A solution prepared to be initially 1 M in Na_2CO_3 and 1 M in CH_3COONa

10. A solution prepared to be initially 0.5 M in CH_3COOH and 1 M in CH_3COONa

74. A solution of calcium hypochlorite, a common additive to swimming-pool water, is...

- (A) basic because of the hydrolysis of the OCl^- ion
- (B) basic because $\text{Ca}(\text{OH})_2$ is a weak and insoluble base
- (C) neutral if the concentration is kept below 0.1 molar
- (D) acidic because of the hydrolysis of the Ca^{2+} ions
- (E) acidic because the acid HOCl is formed



The reaction represented above has an equilibrium constant equal to 3.7×10^4 . Which of the following can be concluded from this information?

- (A) $\text{CN}^-(\text{aq})$ is a stronger base than $\text{C}_2\text{H}_3\text{O}_2^-(\text{aq})$
- (B) $\text{HCN}(\text{aq})$ is a stronger acid than $\text{HC}_2\text{H}_3\text{O}_2(\text{aq})$
- (C) The conjugate base of $\text{CN}^-(\text{aq})$ is $\text{C}_2\text{H}_3\text{O}_2^-(\text{aq})$
- (D) The equilibrium constant will increase with an increase in temperature.
- (E) The pH of a solution containing equimolar amounts of $\text{CN}^-(\text{aq})$ and $\text{HC}_2\text{H}_3\text{O}_2(\text{aq})$ is 7.0

52. When dilute nitric acid was added to a solution of one of the following chemicals, a gas was evolved, This gas turned a drop of limewater, $\text{Ca}(\text{OH})_2$, cloudy, due to the formation of a white precipitate. The chemical was...

- (A) household ammonia, NH_3
- (B) baking soda, NaHCO_3
- (C) table salt, NaCl
- (D) epsom salts, $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$
- (E) bleach, 5% NaOCl

Questions 9-12 refer to aqueous solutions containing 1:1 mole ratios of the following pairs of substances. Assume all concentrations are 1 M.

- (A) NH_3 and NH_4Cl (B) H_3PO_4 and NaH_2PO_4 (C) HCl and NaCl
(D) NaOH and NH_3 (E) NH_3 and $\text{HC}_2\text{H}_3\text{O}_2$ (acetic acid)

9. The solution with the lowest pH
10. The most nearly neutral solution
11. A buffer at a $\text{pH} > 8$
12. A buffer at a $\text{pH} < 6$

69. Correct procedures for a titration include which of the following?

- I. Draining a pipet by touching the tip to the side of the container used for the titration
II. Rinsing the buret with distilled water just before filling it with the liquid to be titrated
III. Swirling the solution frequently during the titration

- (A) I only (B) II only (C) I and III only (D) II and III only (E) I, II, and III

70. To determine the molar mass of a solid monoprotic acid, a student titrated a weighed sample of the acid with standardized aqueous NaOH . Which of the following could explain why the student obtained a molar mass that was too large?

- I. Failure to rinse all acid from the weighing paper into the titration vessel
II. Addition of more water than was needed to dissolve the acid
III. Addition of some base beyond the equivalence point

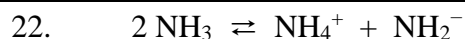
- (A) I only (B) III only (C) I and II only (D) II and III only (E) I, II, and III

24. The safest and most effective emergency procedure to treat an acid splash on skin is to do which of the following immediately?

- (A) Dry the affected area with paper towels
(B) Sprinkle the affected area with powdered $\text{Na}_2\text{SO}_4(\text{s})$
(C) Flush the affected area with water and then with a dilute NaOH solution
(D) Flush the affected area with water and then with a dilute NaHCO_3 solution
(E) Flush the affected area with water and then with a dilute vinegar solution

32. The net ionic equation for the reaction between silver carbonate and hydrochloric acid is...

- (A) $\text{Ag}_2\text{CO}_3(\text{s}) + 2 \text{H}^+ + 2 \text{Cl}^- \rightarrow 2 \text{AgCl}(\text{s}) + \text{H}_2\text{O} + \text{CO}_2(\text{g})$
(B) $2 \text{Ag}^+ + \text{CO}_3^{2-} + 2 \text{H}^+ + 2 \text{Cl}^- \rightarrow 2 \text{AgCl}(\text{s}) + \text{H}_2\text{O} + \text{CO}_2(\text{g})$
(C) $\text{CO}_3^{2-} + 2 \text{H}^+ \rightarrow \text{H}_2\text{O} + \text{CO}_2(\text{g})$
(D) $\text{Ag}^+ + \text{Cl}^- \rightarrow \text{AgCl}(\text{s})$
(E) $\text{Ag}_2\text{CO}_3(\text{s}) + 2 \text{H}^+ \rightarrow 2 \text{Ag}^+ + \text{H}_2\text{CO}_3$



In liquid ammonia, the reaction represented above occurs. In the reaction NH_4^+ acts as...

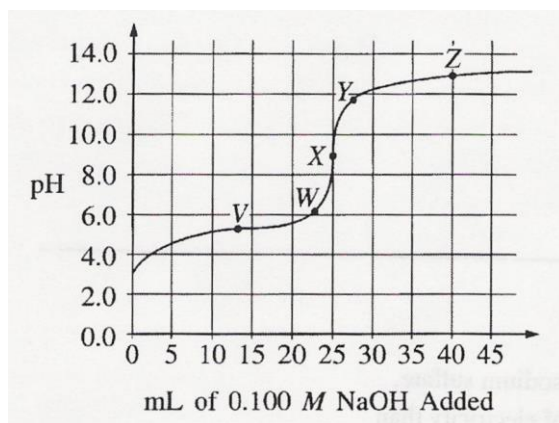
- (A) a catalyst
- (B) both an acid and a base
- (C) the conjugate acid of NH_3
- (D) the reducing agent
- (E) the oxidizing agent

30. At 25°C , aqueous solutions with a pH of 8 have a hydroxide ion concentration, $[\text{OH}^-]$, of...

- (A) $1 \times 10^{-14} \text{ M}$
- (B) $1 \times 10^{-8} \text{ M}$
- (C) $1 \times 10^{-6} \text{ M}$
- (D) 1M
- (E) 8M

Questions 33-34

The graph below shows the titration curve that results when 100. mL of 0.0250 M acetic acid is titrated with 0.100 M NaOH.



33. Which of the following indicators is the best choice for this titration?

- | | pH Range of
Color Change |
|---------------------|-----------------------------|
| (A) Methyl orange | 3.2 - 4.4 |
| (B) Methyl red | 4.8 - 6.0 |
| (C) Bromthymol blue | 6.1 - 7.6 |
| (D) Phenolphthalein | 8.2 - 10.0 |
| (E) Alizarin | 11.0 - 12.4 |

34. What part of the curve corresponds to the optimum buffer action for the acetic acid/acetate pair?

- (A) Point V
- (B) Point X
- (C) Point Z
- (D) Along all of section WY
- (E) along all of section YZ

61. How can 100. mL of sodium hydroxide solution with a pH of 13.00 be converted to a sodium hydroxide solution with a pH of 12.00?

- (A) By diluting the solution with distilled water to a total volume of 108 mL
- (B) By diluting the solution with distilled water to a total volume of 200 mL
- (C) By diluting the solution with distilled water to a total volume of 1.00 L
- (D) By adding 100. mL of 0.10 M HCl
- (E) By adding 100. mL of 0.10 M NaOH

63. Mixtures that would be considered buffers include which of the following?

- I. 0.10 M HCl + 0.10 M NaCl
- II. 0.10 M HF + 0.10 M NaF
- III. 0.10 M HBr + 0.10 M NaBr

- (A) I only
- (B) II only
- (C) III only
- (D) I and II
- (E) II and III

64. Ascorbic acid $\text{H}_2\text{C}_6\text{H}_6\text{O}_6(\text{s})$, is a diprotic acid with $K_1 = 7.9 \times 10^{-5}$ and $K_2 = 1.6 \times 10^{-12}$. In a 0.005 M aqueous solution of ascorbic acid, which of the following species is present in the lowest concentration?

- (A) $\text{H}_2\text{O}(\text{l})$
- (B) $\text{H}_3\text{O}^+(\text{aq})$
- (C) $\text{H}_2\text{C}_6\text{H}_6\text{O}_6(\text{aq})$
- (D) $\text{HC}_6\text{H}_6\text{O}_6^-(\text{aq})$
- (E) $\text{C}_6\text{H}_6\text{O}_6^{2-}(\text{aq})$

74. A pure white crystalline solid dissolves in water to yield a basic solution that liberates a gas when excess acid is added to it. On the basis of this information, the solid could be...

- (A) KNO_3
- (B) K_2CO_3
- (C) KOH
- (D) KHSO_4
- (E) KCl

74. Equal volumes of 0.10-molar H_3PO_4 and 0.20-molar KOH are mixed. After equilibrium is established, the type of ion a solution in largest concentration, other than the K^+ ion, is...

- (A) H_2PO_4^-
- (B) HPO_4^{2-}
- (C) PO_4^{3-}
- (D) OH^-
- (E) H_3O^+