AP Chemistry Acid–Base Practice

Use this key to check answers and read the explanations.

1. In the model equation $HA + B \rightleftharpoons A^- + HB^+$, which species acts as the base in the forward direction?

A. B
B. HA
C. HB^+
D. A^-

Correct answer: A. B
B accepts a proton from HA to become HB^+. A Brønsted–Lowry base accepts a proton.

2. A model ion Q^- acts as a base and gains one proton. What is its conjugate acid?

A. HQ^-
B. Q^{2-}
C. HQ
D. HQ^+

Correct answer: C. HQ
Adding H^+ to Q^- gives HQ. The single negative charge and single positive charge sum to zero.

3. One model solution has pH 4.00 and a second has pH 6.00. How does the first solution’s hydronium concentration compare with the second’s?

A. It is twice as large.
B. It is 100 times as large.
C. It is 10 times as large.
D. It is 100 times smaller.

Correct answer: B. It is 100 times as large.
Each pH unit corresponds to a factor of ten in hydronium concentration. A difference of two units gives a factor of 100, with more hydronium at the lower pH.

4. Two fictional monoprotic acid solutions start with the same dissolved acid concentration. A larger fraction of acid particles ionizes in X than in Y. Which acid is stronger in this comparison?

A. The strength depends only on the size of the sample.
B. The acid in Y
C. Both strengths must be equal.
D. The acid in X

Correct answer: D. The acid in X
At the same starting concentration, the stronger of these two acids ionizes to a larger extent in water.

5. In a water model, the temperature changes the value of the ion-product constant for water. Which criterion still identifies a neutral solution?

A. The pH is exactly 7.00 at any temperature.
B. Hydronium and hydroxide concentrations are equal.
C. The hydroxide concentration is exactly zero.
D. The pH and the ion-product constant are numerically equal.

Correct answer: B. Hydronium and hydroxide concentrations are equal.
Water is neutral when hydronium and hydroxide concentrations match. The temperature dependence of the ion product can move neutral pH away from 7.00.

6. A simulated aqueous solution at 25 °C has pOH 5.20. Using pH + pOH = 14.00, what is its pH?

A. 8.80
B. 5.20
C. 9.20
D. 19.20

Correct answer: A. 8.80
Subtract 5.20 from 14.00. The pH is 8.80 for the stated temperature model.

7. The simulated hydronium concentration is 2.0×10^{-5} mol/L. Using the usual concentration approximation, what is the pH to two decimal places?

A. 2.00
B. 5.30
C. 5.00
D. 4.70

Correct answer: D. 4.70
The pH is $-\log_{10}(2.0 \times 10^{-5}) = 5 - \log_{10}(2.0)$, or about 4.70.

8. Model acid HX has Ka = 1.0×10^{-4}, and HY has Ka = 1.0×10^{-6} under the same conditions. Which conjugate base is stronger?

A. Both are equally strong.
B. X^-
C. Y^-
D. The formulas do not identify either conjugate base.

Correct answer: C. Y^-
HY has the smaller Ka and is the weaker acid. At fixed temperature, the conjugate base of the weaker acid has the larger Kb.

9. A fictional salt releases an inert spectator cation and A^-, the conjugate base of a weak acid HA. Which statement fits the model aqueous solution?

A. A^- can accept a proton from water, increasing hydroxide.
B. A^- donates a proton to water, increasing hydronium.
C. The spectator cation releases an equal amount of hydronium.
D. The salt makes a neutral solution simply because it contains equal numbers of ions.

Correct answer: A. A^- can accept a proton from water, increasing hydroxide.
A^- can react with water to form HA and OH^-. Since the cation is a spectator, this equilibrium makes the solution basic.

10. Two same-volume model buffers use the same acid and conjugate base in a one-to-one ratio. Buffer A has four times the concentration of each component. Which buffer generally tolerates a larger addition of acid before its pH shifts by the same amount?

A. The ratio determines capacity and concentration determines pH.
B. Buffer B
C. Both tolerate the same addition because the ratio is equal.
D. Buffer A

Correct answer: D. Buffer A
The equal starting ratio gives the same modeled starting pH. Buffer A contains more conjugate base to consume added acid before the ratio changes by the same fraction.

11. An idealized monoprotic weak-acid titration reaches equivalence after 24.0 mL of model base has been added. Why can the curve at 12.0 mL estimate the acid's pKa?

A. The pH has to equal 7.00 in every buffer.
B. All of HA has been converted to A^-.
C. Half of HA has been converted to A^-, so their concentrations are equal.
D. The hydroxide concentration is equal to the initial acid concentration.

Correct answer: C. Half of HA has been converted to A^-, so their concentrations are equal.
The half-equivalence point has equal amounts of weak acid and conjugate base in the same volume. The log of their concentration ratio is zero, so pH equals pKa in the model.

12. A fictional diprotic model acid H_2D starts with 0.018 mol. Each unit of a model base removes one proton. How many moles of base does the model require to reach the second equivalence point?

A. 0.018 mol
B. 0.036 mol
C. 0.009 mol
D. 0.054 mol

Correct answer: B. 0.036 mol
The second equivalence point represents two proton removals per starting unit of H_2D. Multiply 0.018 mol by two.

13. A fictional buffer contains 0.009 mol A^- and 0.006 mol HA. A modeled proton input converts 0.003 mol A^- to HA with negligible volume change. What happens to the pH relative to pKa?

A. It finishes exactly at pKa.
B. It moves from below pKa to above pKa.
C. It stays above pKa the whole time.
D. It moves from above pKa to below pKa.

Correct answer: D. It moves from above pKa to below pKa.
The ratio of A^- to HA starts at 0.009/0.006 = 1.5 and ends at 0.006/0.009, or about 0.67. The log of the ratio changes from positive to negative.

14. At 25 °C, two idealized titrations use the same strong base. One starts with a strong monoprotic acid; the other starts with a weak monoprotic acid. Which solution has the higher pH at its own equivalence point?

A. The weak-acid solution, because its conjugate base reacts with water.
B. The strong-acid solution, because its anion attracts more protons.
C. They must have the same pH because the starting acids have one removable proton.
D. The weak-acid solution, because extra titrant has already been added.

Correct answer: A. The weak-acid solution, because its conjugate base reacts with water.
At weak-acid equivalence the solution contains a conjugate base that can form hydroxide through hydrolysis. At ideal strong-acid equivalence the ions are spectators and pH is about 7.00.

15. A model starts with 0.210 mol/L HA and no added A^-. At equilibrium, 0.010 mol/L HA has ionized and water's own ionization is negligible. What is the concentration-based Ka?

A. 5.0×10^{-2}
B. 4.8×10^{-4}
C. 5.0×10^{-4}
D. 2.0×10^{-3}

Correct answer: C. 5.0×10^{-4}
At equilibrium [HA] = 0.200 mol/L and $[H_3O^+] = [A^-] = 0.010$ mol/L. Divide their product, 0.00010, by 0.200 to get 5.0×10^{-4}.