Ionic Equilibria

15 Hard Multiple-Choice Questions

Theoretical Concepts + Calculation Problems

Format	Choose the single best answer (A-E).
Coverage	Acid-base theories, solvent classification, salts, polyprotic electrolytes, ampholytes, water ionization, pH calculations, salt hydrolysis, buffers, mixed weak acids, and ampholyte pH.
Answer key	Model answers are placed at the end of the file.

Questions

1. Which statement most accurately summarizes the pharmaceutical consequences of drug ionization described in this chapter?

A) Unionized drug is usually more water-soluble and is excreted more readily.

B) Ionized drug diffuses across membranes more readily, whereas unionized drug remains in plasma.

C) Ionized drug is generally more soluble in aqueous formulation, unionized drug crosses membranes more readily, and ionized drug is excreted more readily.

D) Ionization affects formulation only and has essentially no effect on absorption or excretion.

E) Unionized drug always has the lower volume of distribution and the lower protein binding.

2. HCl behaves as a weak acid in glacial acetic acid, whereas acetic acid behaves as a strong acid in liquid ammonia. Which interpretation best follows the Bronsted-Lowry discussion?

A) Acid strength is an absolute property and is independent of the solvent.

B) Acid strength depends on both proton donation by the acid and proton acceptance by the solvent.

C) Liquid ammonia is aprotic and therefore cannot interact with acids.

D) Glacial acetic acid is a stronger proton acceptor than water.

E) The observations can only be explained by Lewis theory, not Bronsted-Lowry theory.

3. Which set of solvent classifications is completely consistent with the chapter?

A) Liquid NH_3: protogenic; CH_3COOH: protophilic; H_2O: aprotic; CH_4: amphiprotic.

B) Liquid NH_3: aprotic; CH_3COOH: amphiprotic; H_2O: protogenic; CH_4: protophilic.

C) Liquid NH_3: amphiprotic; CH_3COOH: aprotic; H_2O: protophilic; CH_4: protogenic.

D) Liquid NH_3: protophilic; CH_3COOH: protogenic; H_2O: amphiprotic; CH_4: aprotic.

E) Liquid NH_3: protogenic; CH_3COOH: aprotic; H_2O: amphiprotic; CH_4: protophilic.

4. Why can BF_3 be classified as an acid under Lewis electronic theory even though it contains no hydrogen?

A) It donates OH^- ions in water.
B) It accepts an electron pair to form a covalent bond.
C) It accepts a proton from every Bronsted acid.
D) It supplies an unshared electron pair to a Lewis acid.
E) It must first hydrolyze to HBF_4 before showing acidic behavior.

5. Which description of sodium acetate in water is correct?

A) Na^+ releases a proton and produces an acidic solution.
B) Acetate is neutral because it originates from an acid.
C) Acetate consumes a proton from water to form HOAc, producing OH^- and a basic solution.
D) Both Na^+ and acetate are strong acids in water.
E) Sodium acetate behaves exactly like NaCl and leaves the pH at 7 under all conditions.

6. For a weak diprotic acid H_2CO_3, which relationship and interpretation are most consistent with the chapter?

A) $K_{a1} > K_{a2}$ because the first proton is lost more readily than the second.
B) $K_{a1} = K_{a2}$ because both protons originate from the same molecule.
C) $K_{a2} > K_{a1}$ because removal of the first proton makes the second proton easier to remove.
D) Only one ionization constant is needed for any polyprotic acid.
E) The pH of a weak diprotic acid must always be calculated from K_{a2} only.

7. Which statement about glycine isoelectric behavior is correct?

A) The zwitterion can act only as an acid and never as a base.
B) At the isoelectric point, glycine is completely unionized and electrically neutral at every atom.
C) The isoelectric point is the pH at which the fully protonated form is at maximum concentration.
D) At the isoelectric point, glycine moves rapidly toward the anode because the positive charge dominates.
E) At the isoelectric point, zwitterion concentration is maximal and net movement in an electric field is negligible.

8. [Calculation] What is the pH of a 2.50×10^{-3} M solution of a strong monoprotic acid, assuming complete ionization?

A) 1.60
B) 2.60
C) 3.40
D) 11.40
E) 12.40

9. [Calculation] A weak acid has $pK_a = 4.60$ and concentration 0.040 M. Using the weak-acid approximation from the chapter, what is its pH?

A) 2.30
B) 2.60
C) 2.80
D) 3.00
E) 4.60

10. [Calculation] A weak base has concentration 0.025 M and the pKa of its conjugate acid is 9.20. At 25 C, what pH is predicted by the chapter equation?

A) 8.20
B) 9.60
C) 10.80
D) 11.60
E) 12.20

11. [Calculation] Sodium benzoate is a salt of a weak acid and a strong base. If pKa of benzoic acid is 4.20 and the salt concentration is 0.020 M, what is the approximate pH at 25 C?

A) 8.25
B) 7.00
C) 5.75
D) 4.20
E) 9.95

12. [Calculation] A buffer contains 0.20 M acetic acid and 0.050 M sodium acetate. If pKa = 4.76, what is the pH?

A) 3.56
B) 3.86
C) 4.00
D) 4.16
E) 5.36

13. For a salt formed from a weak acid and a weak base, which expression is given in the chapter for its pH?

A) pH = pKa + log([salt]/[acid])
B) pH = 0.5(pKw + pKa - pKb)
C) pH = 0.5(pKa - log[salt])
D) pH = pKw + log[salt]
E) pH = 0.5(pKw + pKb + log[salt])

14. [Calculation] A solution contains two weak acids: acid 1 has Ka = 1.8 x 10^-5 and C = 0.010 M; acid 2 has Ka = 1.0 x 10^-6 and C = 0.020 M. Using [H3O+] = sqrt(Ka1C1 + Ka2C2), what is the pH?

A) 2.70
B) 2.95
C) 3.10
D) 3.23
E) 3.35

15. [Calculation] An ampholyte has pK1 = 2.34 and pK2 = 9.60. What pH is predicted for a solution containing only this ampholyte?

A) 4.63
B) 5.31
C) 5.97
D) 6.82
E) 7.13

Model Answers

Correct answers are listed below. Calculation items include a compact numerical check.

Q	Answer	Correct option / result
1	**C**	Ionized drug is more water-soluble for formulation; unionized drug crosses membranes more readily; ionized drug is excreted more readily.
2	**B**	Bronsted-Lowry acid strength depends on proton donation by the acid and the ability of the solvent to accept that proton.
3	**D**	NH3 is protophilic, CH3COOH protogenic, H2O amphiprotic, and CH4 aprotic.
4	**B**	A Lewis acid accepts an electron pair. BF3 therefore qualifies even without being a proton donor.
5	**C**	OAc- + H2O <> HOAc + OH-. Hydrolysis of acetate makes the solution basic.
6	**A**	For a weak polyprotic acid, the first proton is lost more readily, so Ka1 is larger than Ka2.
7	**E**	The zwitterion predominates at the isoelectric point and its net electrophoretic movement is negligible.
8	**B**	pH = -log(2.50 x 10^-3) = 2.60.
9	**D**	pH = 0.5[pKa - log(HA)] = 0.5[4.60 - log(0.040)] = about 3.00.
10	**C**	pH = 0.5[pKw + pKa + log(B)] = 0.5[14 + 9.20 + log(0.025)] = about 10.80.
11	**A**	pH = 0.5[pKw + pKa + log(S)] = 0.5[14 + 4.20 + log(0.020)] = about 8.25.
12	**D**	pH = pKa + log(S/HA) = 4.76 + log(0.050/0.20) = about 4.16.
13	**B**	For a salt of a weak acid and weak base: pH = 0.5(pKw + pKa - pKb).
14	**E**	[H3O+] = sqrt[(1.8 x 10^-5)(0.010) + (1.0 x 10^-6)(0.020)] = 4.47 x 10^-4 M; pH = 3.35.
15	**C**	pH = 0.5(pK1 + pK2) = 0.5(2.34 + 9.60) = 5.97.

End of Question Set