

Buffered Solutions

15 Hard Multiple-Choice Questions

Theoretical Concepts + Calculation Problems

Format	Choose the single best answer (A-E).
Coverage	Buffer equation, buffer mechanism, buffer capacity, maximum capacity, biological buffers, pharmaceutical buffering, tissue irritation, stability, solubility, and buffer design.
Answer key	Model answers are placed at the end of the file.

Questions

1. Which mixture most directly represents a buffer according to the chapter?

- A) A strong acid and a strong base in exactly equal amounts.
- B) A weak acid and its conjugate-base salt, or a weak base and its conjugate-acid salt.
- C) A strong acid and its salt with a strong base only.
- D) A nonelectrolyte dissolved in distilled water.
- E) Any two salts at the same molar concentration.

2. When a small amount of strong acid is added to an acetate buffer, what is the principal buffering event?

- A) Acetic acid donates OH^- to neutralize the acid.
- B) Water permanently removes H_3O^+ without involving the buffer components.
- C) The salt completely precipitates, removing all added acid.
- D) Acetate ion consumes the added H_3O^+ and is converted to weak acetic acid.
- E) The pK_a of acetic acid increases until the original pH is restored.

3. [Calculation] An acetate buffer contains 0.15 M acetic acid and 0.030 M sodium acetate. If $\text{pK}_a = 4.76$, what is the pH?

- A) 3.36
- B) 3.76
- C) 4.06
- D) 4.46
- E) 5.46

4. [Calculation] How many moles of sodium acetate must be added to 100 mL of 0.10 M acetic acid to obtain pH 5.20? Assume $pK_a = 4.76$ and no volume change.

- A) 0.00275 mol
- B) 0.0100 mol
- C) 0.0175 mol
- D) 0.0275 mol
- E) 0.0550 mol

5. Which definition of buffer capacity is used in the chapter?

- A) The quantity of strong acid or base that changes the pH of 1 L of buffer by one pH unit.
- B) The number of moles of weak acid present at $pH = 7$.
- C) The ratio of salt concentration to acid concentration.
- D) The amount of water required to dilute a buffer to half its original concentration.
- E) The pH difference between a buffer and pure water.

6. [Calculation] For a buffer with total concentration $C = 0.20$ M, $K_a = 1.75 \times 10^{-5}$, and $[H_3O^+] = 1.00 \times 10^{-5}$ M, use $\beta = 2.3C K_a [H_3O^+] / (K_a + [H_3O^+])^2$. What is β ?

- A) 0.021
- B) 0.058
- C) 0.106
- D) 0.200
- E) 0.460

7. [Calculation] What is the maximum buffer capacity of a buffer whose total concentration is 0.050 M, using $\beta_{\text{max}} = 0.576C$?

- A) 0.0050
- B) 0.0288
- C) 0.0500
- D) 0.0576
- E) 0.1152

8. Which change would be expected to increase buffer capacity most effectively, assuming all other conditions remain suitable?

- A) Move the salt/acid ratio far away from 1 while lowering both concentrations.
- B) Dilute the buffer until one component is nearly absent.
- C) Keep total concentration constant but remove all conjugate base.
- D) Use a strong acid alone at the same pH.
- E) Increase the total concentration and keep the salt/acid ratio near 1.

9. Which sequence best matches the chapter approach to developing a new pharmaceutical buffer?

- A) Choose any strong acid, maximize buffer capacity, then ignore toxicity if pH is correct.
- B) Select a weak acid with pKa near target pH, calculate salt/acid ratio, choose suitable concentrations, consider factors such as toxicity and stability, then verify final pH and buffer capacity.
- C) Select the most concentrated salt available, then adjust pH only after sterilization.
- D) Begin with borate for every oral and parenteral product because it is universally safe.
- E) Choose pKa far from the desired pH to minimize ionization.

10. [Calculation] A weak-acid buffer has pKa = 4.76. At pH 5.76, what is the required ratio [salt]/[acid]?

- A) 10:1
- B) 5:1
- C) 2:1
- D) 1:1
- E) 1:10

11. Which statement about biological buffering is consistent with the chapter?

- A) Blood pH is maintained mainly by borate buffer.
- B) Blood pH is maintained near 7.4 by bicarbonate, phosphate, and erythrocyte buffers.
- C) Body fluids have negligible buffer capacity and therefore tolerate almost no pH variation.
- D) Erythrocytes do not participate in buffering because hemoglobin cannot bind protons.
- E) Physiological buffers function only when pH is below 4.

12. If a pharmaceutical solution has a pH very different from the relevant body fluid, tissue irritation is expected to be minimized when:

- A) Both the solution and physiological fluid have low volume and low buffer capacity.
- B) The pharmaceutical solution has high volume and high buffer capacity.
- C) The physiological fluid has low volume and the dosage form has high buffer capacity.
- D) The pharmaceutical solution has low volume and low buffer capacity, while the physiological fluid has high volume and high buffer capacity.
- E) The dosage form is strongly buffered exactly at its stability pH regardless of tissue pH.

13. For an ophthalmic drug whose pH of maximum stability differs substantially from its pH of maximum therapeutic action, which strategy is recommended in the chapter?

- A) Use the highest possible buffer capacity at the stability pH so tears cannot change it.
- B) Always formulate at pH 7.4 even if the drug is unstable there.
- C) Use a low buffer capacity at a compromise pH between stability and therapeutic action, allowing tears to shift the pH after instillation.
- D) Avoid buffers completely and use only strong acid.
- E) Convert the drug entirely to the undissociated form before administration.

14. Why may increasing the pH of a solution of a weakly basic drug cause precipitation?

- A) More undissociated free base forms, and this form is usually less water-soluble.
- B) The drug becomes more protonated and therefore less soluble.
- C) The ionic form is converted into a stronger electrolyte with lower solubility.
- D) Raising pH always lowers the solubility of every drug, regardless of ionization.
- E) The buffer capacity becomes zero as soon as pH exceeds 7.

15. [Calculation] The pKa of a weak base is 7.15. In tears at pH 7.40, use $\text{pH} = \text{pKa} + \log\left(\frac{[\text{Base}]}{[\text{Salt}]}\right)$. Approximately what mole percent is present as free base?

- A) 18%
- B) 36%
- C) 50%
- D) 64%
- E) 82%

Model Answers

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

Q	Answer	Correct option / result
1	B	A buffer is composed of a weak acid plus its conjugate-base salt, or a weak base plus its conjugate-acid salt.
2	D	Added H_3O^+ is consumed by the conjugate base (acetate), producing the weak acid and limiting the pH change.
3	C	$\text{pH} = \text{pK}_a + \log(\text{S}/\text{HA}) = 4.76 + \log(0.030/0.15) = \text{about } 4.06.$
4	D	$5.20 - 4.76 = \log(\text{S}/0.10)$, so $\text{S} = 0.2754 \text{ M}$. In 0.100 L: moles = 0.02754 mol.
5	A	Buffer capacity is the quantity of strong acid or base required to change the pH of 1 L of buffer by one pH unit.
6	C	$\beta = 2.3(0.20)(1.75 \times 10^{-5})(1.00 \times 10^{-5})/(2.75 \times 10^{-5})^2 = \text{about } 0.106.$
7	B	$\beta(\text{max}) = 0.576\text{C} = 0.576 \times 0.050 = 0.0288 \text{ mol/L per pH unit}.$
8	E	Capacity increases as the salt/acid ratio approaches 1 and as the total buffer concentration increases.
9	B	The chapter recommends pK_a near target pH, calculating the ratio, selecting suitable concentrations, considering practical constraints, and verifying pH and capacity.
10	A	$\text{pH} - \text{pK}_a = 1.00 = \log(\text{S}/\text{HA})$, so $\text{S}/\text{HA} = 10.$
11	B	Blood is maintained near pH 7.4 by bicarbonate, phosphate, and erythrocyte buffer systems.
12	D	Irritation is minimized when the dosage form has low volume/capacity and the physiological fluid has high volume/capacity.
13	C	A low-capacity compromise buffer allows physiological fluid such as tears to move pH toward the therapeutically favorable value.
14	A	At higher pH a weak base becomes more unionized; the free base is usually less water-soluble and may precipitate.
15	D	$[\text{Base}]/[\text{Salt}] = 10^{(7.40-7.15)} = 1.78$. Fraction base = $1.78/(1+1.78) = \text{about } 0.64$, or 64%.

End of Question Set