Buffer Solutions Worksheet

Organic Chemistry Tutor

1. What is the pH of a solution consisting of 0.75 M $HC_2H_3O_2$ and 0.50 M $NaC_2H_3O_2$? The K_a of $HC_2H_3O_2$ is 1.8×10^{-5}.

2. What is the pH of a solution containing 0.15 mol of NH_4Cl and 1.5 mol of NH_3? (The K_b of NH_3 is 1.8×10^{-5})

3. Calculate the pH of a solution containing 15g of HF and 21g of NaF in 750 mL of solution. (The K_a of HF is $7.2 \times 10^{-}4$)

4. What is the pK_a of an unknown weak acid if the pH of the solution was measured to be 5.62 when [HA] = 0.450 M and $[A^-]$ = 0.850 M?

5. The pK_a of HCN is 9.21. (a) What is the ratio of $[CN^-]$ to [HCN] if the pH of the solution is 9.85? (b) If [HCN] = 0.25 M at a pH of 9.85, what will be the concentration of $[CN^-]$?

6. Calculate the mass of NaF in grams that must be dissolved in a 0.25 M HF solution to form a 300 mL buffer solution with a pH of 3.5. (K_a for HF is 7.2×10^{-4})

7. The K_a of a certain weak acid (HX) is 1×10^{-9}. (a) If $[X^-]$ is ten times [HX], what is the pH of the solution? (b) What is the concentration of H_3O^+ in this solution?

8. The K_a values for certain acids are listed below: Which of the following will be ideal to create a buffer solution centered at a pH of 7.1?

HF:	$K_a = 7.2 \times 10^{-4}$
$HC_2H_3O_2$:	$K_a = 1.8 \times 10^{-5}$
HOCl:	$K_a = 3.5 \times 10^{-8}$
$H_2PO_4^-$:	$K_a = 6.2 \times 10^{-8}$
NH_4^+:	$K_a = 5.6 \times 10^{-10}$

A. HF / NaF
B. $HC_2H_3O_2$ / $NaC_2H_3O_2$
C. HOCl / KOCl
D. NaH_2PO_4 / Na_2HPO_4
E. NH_4Cl / NH_3

9. Which of the following statements is false?

A. The pH of a buffer solution is equal to the pK_a of the weak acid when $[HA] = [A^-]$

B. Buffer solutions are resistant to pH changes when a strong acid or a strong base is added to it.

C. A buffer solution is composed of a weak acid and its conjugate weak base.

D. The pH of a buffer solution is greater than the pK_a of HA when $[A^-] > [HA]$.

E. The pH of a buffer solution will differ from the pK_a of HA by 2 units when $[A^-]$ is ten times greater than [HA].

10. A buffer solution is prepared from mixing 80 mL of a 0.40 M NH_3 solution with 120 mL of a 0.30 M NH_4Cl solution. The K_a for NH_4^+ is 5.56×10^{-10}. (a) What is the pH of the solution? (b) Calculate $[H_3O^+]$.

11. Which of the following combinations represents a buffer solution?

A. HCl and NaCl
B. HF and NaOH
C. HCl and NaOH
D. NH_3 and HF
E. HCN and NaCN

12. Which of the following combinations will produce a buffer solution?

A. 100 mL of 0.40 M HCl + 50 mL of 0.50 M NaCl

B. 80 mL of 0.50 M NH_3 + 60 mL of 0.60 M NaOH

C. 70 mL of 0.60 M HCl + 50 mL of 0.50 M NH_3

D. 80 mL of 0.50 M NaOH + 70 mL of 0.80 M HF

E. 60 mL of 0.60 M HCl + 50 mL of 0.80 M HCN

13. 50 mL of a 0.30 M NaOH solution is added to 100 mL of a 0.45 M HCN solution. What is the pH of the resulting mixture? (The K_a for HCN is 6.2×10^{-10})

14. Which of the following solutions has the greatest buffering capacity? (Assume each solution have the same volume)

A. 0.10 M HF / 0.10 M NaF
B. 0.50 M HF / 0.50 M NaF
C. 3.0 M HF / 3.0 M NaF
D. 1.0 M HF / 1.0 M NaF

15. Calculate the change in pH that occurs when 100 mL of a 0.05 M HCl solution is added to (a) 100 mL of water. (b) 100 mL of a buffer solution containing 0.10 M NH_3 and 0.10 M NH_4Cl. (c) 100 mL of a buffer solution containing 1.0 M NH_3 and 1.0 M NH_4Cl. (d) Describe the function of a buffer solution based on the answers found in parts (a) and (b). (e) Describe the concept of buffering capacity with respect to pH changes calculated in parts (b) and (c).

16. How many mL of a 0.80 M NaOH solution must be added to 300 mL of a 0.30 M NH_4Cl solution to make a buffer with a pH of 10.0? (The pK_a of NH_4^+ is 9.25527)

Answers:

1. pH = 4.57
2. pH = 10.26
3. pH = 2.97
4. $pK_a = 5.34$

5a. $[CN^-] / [HCN] = 4.365$
5b. $[CN^-] = 1.09$ M

6. 7.17g of NaF

7a. pH = 10
7b. $[H_3O^+] = 1 \times 10^{-10}$ M

8. D
9. E

10a. pH = 9.20
10b. $[H_3O^+] = 6.3 \times 10^{-10}$ M

11. E
12. D
13. pH = 8.91
14. C

15a. ΔpH = -5.40
15b. ΔpH = -0.477
15c. ΔpH = -0.0435
15d. A buffer solution is designed to reduce changes in the pH of a solution.
15e. A buffer with a larger buffer capacity will be more resistant to pH changes compared to a buffer with a smaller buffer capacity.

16. 95.3 mL