Name _____ **Date** _____ **Period** _____

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AP Chemistry Unit 8 Study Guide

Acids and Bases (Topics 8.1 to 8.11)

Show all work with units and correct significant figures. All solutions are at 25 °C unless a question says otherwise. When you explain, name the species that react and say what happens to their concentrations.

Constants	$K_w = 1.0 \times 10^{-14}$ at 25 °C	$pK_w = 14.00$ at 25 °C	Neutral water: pH = 7.00 at 25 °C
Equations	$pH = -\log[H_3O^+]$	$pOH = -\log[OH^-]$	$pH + pOH = 14.00$
	$[H_3O^+] = 10^{-pH}$	$K_a = [H_3O^+][A^-] / [HA]$	$K_b = [OH^-][HB^+] / [B]$
	$K_a \times K_b = K_w$	$pK_a = -\log K_a$	$pK_a + pK_b = 14.00$
	$pH = pK_a + \log([A^-] / [HA])$	% ionization $= ([H_3O^+] / [HA]_0) \times 100$	$n = M \times V$

Part 1. pH, pOH, and Strong Acids and Bases (Topics 8.1 to 8.2)

1. Complete the table for three solutions at 25 °C.

$[H_3O^+]$ (M)	$[OH^-]$ (M)	pH	pOH	Acidic, basic, or neutral?
2.5×10^{-4}				
		9.15		
	3.2×10^{-2}			

2. Calculate the pH of each solution.

(a) 0.0040 M HNO_3

(b) 0.0025 M $Ba(OH)_2$

3. At 50 °C, $K_w = 5.5 \times 10^{-14}$.

(a) Calculate the pH of pure water at 50 °C.

(b) A student says this water is acidic because its pH is less than 7. Do you agree or disagree? Explain.

(c) Is the autoionization of water endothermic or exothermic? Justify your answer.

Part 2. Weak Acids and Weak Bases (Topic 8.3)

4. Benzoic acid, $HC_7H_5O_2$, is a weak acid with $K_a = 6.3 \times 10^{-5}$. A solution is 0.15 M benzoic acid.

(a) Write the equation for the ionization of benzoic acid in water.

(b) Calculate the pH of the solution.

(c) Calculate the percent ionization.

(d) The solution is diluted to 0.015 M. Circle one: the percent ionization **increases / decreases / stays the same**. Explain.

5. Calculate the pH of 0.30 M NH_3 ($K_b = 1.8 \times 10^{-5}$).

6. A 0.050 M solution of a monoprotic weak acid, HA, has a pH of 3.20. Calculate K_a for HA and its percent ionization.

7. Complete the table. Then rank the three conjugate bases from weakest to strongest.

Acid	K_a	pK_a	Conjugate base	K_b of conjugate base
$HC_2H_3O_2$	1.8×10^{-5}			
HOCl	3.0×10^{-8}			
HCN	6.2×10^{-10}			

8. Decide whether each statement is true or false. Rewrite each false statement so it is true.

Statement	T or F	Correction (if false)
0.10 M HCl and 0.10 M $HC_2H_3O_2$ have the same pH.		
Most $HC_2H_3O_2$ in a 0.10 M solution stays un-ionized.		
NH_3 is a base because the lone pair on N accepts a proton.		
NaCl(aq) is slightly basic because Cl^- reacts with water.		

Part 3. Acid-Base Reactions (Topic 8.4)

9. Each mixture below reacts completely. Identify the major species left (other than H_2O), and classify the final solution as acidic, basic, neutral, or a buffer.

Mixture	Major species after reaction	Acidic, basic, neutral, or buffer?
50.0 mL 0.10 M HCl + 50.0 mL 0.10 M NaOH		
50.0 mL 0.10 M $HC_2H_3O_2$ + 25.0 mL 0.10 M NaOH		
50.0 mL 0.10 M $HC_2H_3O_2$ + 50.0 mL 0.10 M NaOH		
50.0 mL 0.10 M NH_3 + 50.0 mL 0.10 M HCl		

10. Calculate the pH after 40.0 mL of 0.100 M HCl is mixed with 25.0 mL of 0.100 M NaOH.

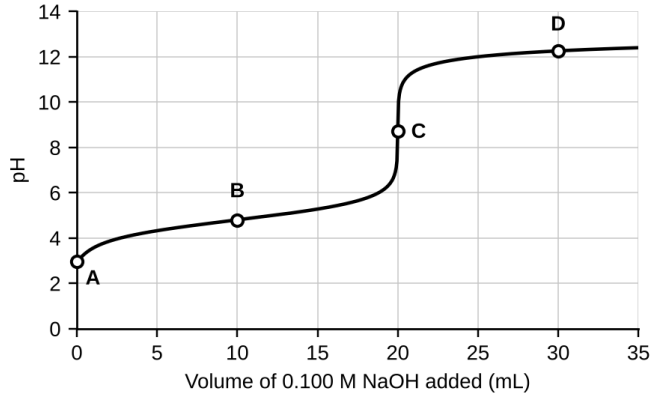
11. Aqueous HF ($K_a = 6.8 \times 10^{-4}$) is mixed with aqueous NH_3 ($K_b = 1.8 \times 10^{-5}$).

(a) Write the net ionic equation for the reaction and label both conjugate acid-base pairs.

(b) Calculate K for the reaction. Are reactants or products favored?

Part 4. Acid-Base Titrations (Topic 8.5)

12. A 25.0 mL sample of a weak acid, HA, is titrated with 0.100 M NaOH. The titration curve is shown.



(a) Write the net ionic equation for the titration reaction.

(b) Calculate the initial concentration of HA.

13. Use the titration curve for HA from the previous question.

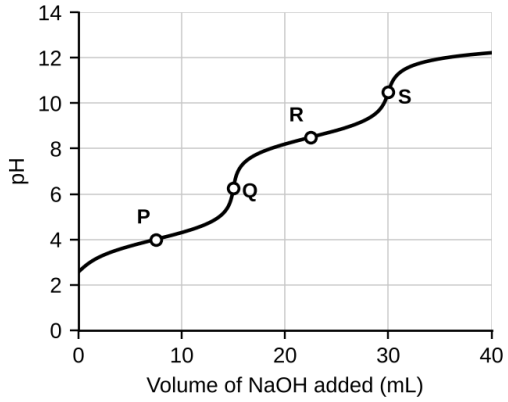
(a) Estimate pK_a and K_a for HA. Explain which point you used.

(b) Complete the table with the major species at each point (ignore Na^+ and H_2O).

Point	**A**	**B**	**C**	**D**
Major species				

(c) Explain why the pH at the equivalence point (C) is greater than 7.

14. The curve shows the titration of a weak acid, H_2A, with NaOH.

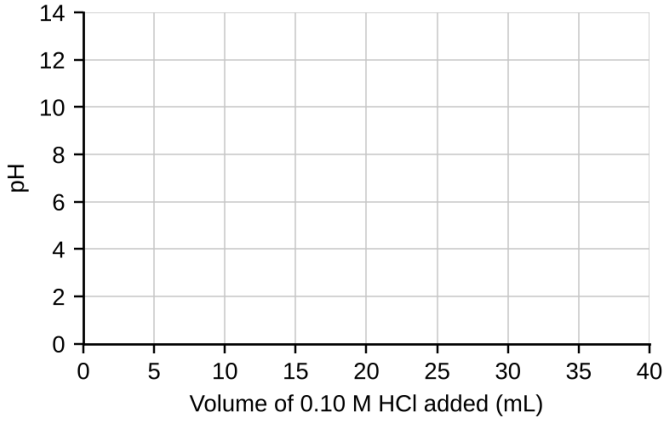


(a) How many acidic protons does H_2A have? How can you tell from the curve?

(b) Estimate pK_{a1} and pK_{a2}.

(c) Identify the major acid-base species at point Q and at point S.

15. On the axes, sketch the titration curve for 20.0 mL of 0.10 M NH_3 titrated with 0.10 M HCl. Label the equivalence point and the half-equivalence point, and give the pH at each (K_b of $NH_3 = 1.8 \times 10^{-5}$).



Part 5. Molecular Structure of Acids and Bases (Topic 8.6)

16. For each pair, identify the stronger acid and explain your choice using molecular structure.

Pair	Stronger acid	Reasoning
HOCl or HOBr		
CH_3COOH or CCl_3COOH		
HClO or $HClO_4$		

17. Acetic acid, CH_3COOH, has four H atoms, but only one of them is acidic. Identify the acidic H atom and explain why the conjugate base, CH_3COO^-, is stabilized.

Part 6. pH, pK_a, and Indicators (Topic 8.7)

18. Lactic acid, HA, has $pK_a = 3.86$. Complete the table for lactic acid in three solutions.

Solution pH	Predominant form (HA, A^-, or equal)	$[A^-] / [HA]$
2.00		
3.86		
7.40		

19. Use the indicator data below.

Indicator	pK_a	Acid form color	Base form color
Methyl orange	3.7	red	yellow
Bromothymol blue	7.1	yellow	blue
Phenolphthalein	9.4	colorless	pink

(a) Which indicator is best for the HA titration in Questions 12 and 13? Explain.

(b) What color is bromothymol blue in a solution with pH = 9.0? Explain using pH and pK_a.

Part 7. Buffers and the Henderson-Hasselbalch Equation (Topics 8.8 to 8.9)

20. A buffer contains 0.25 M NH_3 and 0.40 M NH_4Cl (K_b of NH_3 = 1.8×10^{-5}).

(a) Calculate the pH of the buffer.

(b) Write net ionic equations for the reactions that occur when a small amount of HCl is added and when a small amount of NaOH is added. Explain why the pH changes only slightly.

21. A student needs a buffer with pH = 5.00. Available acids: $HC_2H_3O_2$ (K_a = 1.8×10^{-5}), HOCl (K_a = 3.0×10^{-8}), and HCN (K_a = 6.2×10^{-10}).

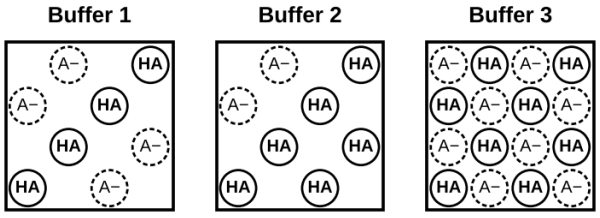
(a) Which acid and its sodium salt should the student use? Explain.

(b) Calculate the mass of $NaC_2H_3O_2$ (82.03 g/mol) to add to 0.500 L of 0.200 M $HC_2H_3O_2$. Assume the volume does not change.

22. Circle each mixture that forms a buffer: **(i)** HCl and NaCl **(ii)** HF and NaF **(iii)** NH_3 and NH_4Cl **(iv)** 0.10 mol $HC_2H_3O_2$ and 0.050 mol NaOH **(v)** 0.10 mol $HC_2H_3O_2$ and 0.10 mol NaOH. Explain why (v) is not a buffer.

Part 8. Buffer Capacity (Topic 8.10)

23. The diagrams show three buffers of the same volume made from a weak acid, HA, and its conjugate base, A^-.



(a) Rank the buffers from lowest to highest pH.

(b) Which buffer can neutralize the most added OH^- before its pH changes sharply? Explain.

(c) Circle one: Buffer 2 is better at neutralizing added **acid / base**. Explain.

Part 9. pH and Solubility (Topic 8.11)

24. Predict the effect of adding HNO_3 on the solubility of each salt, and explain using Le Châtelier's principle.

Salt	Solubility increases, decreases, or little change?	Reason
$Mg(OH)_2$		
CaF_2		
AgCl		