Unit 8 Review

8.1

$$CH_3CH_2COOH(aq) + H_2O(l) \rightleftarrows CH_3CH_2COO^-(aq) + H_3O^+(aq)$$

1. 2. Propanoic acid, CH_3CH_2COOH, is a carboxylic acid that reacts with water according to the equation above. At 25°C the pH of a 50.0 mL sample of 0.20 *M* CH_3CH_2COOH is 2.79.

(a) Identify a Brønsted-Lowry conjugate acid-base pair in the reaction. Clearly label which is the acid and which is the base.

2. Four different examples of acid-base reactions are shown below. In each of these reactions, focus on the H_2O. Decide if $H_2O$is acting as a Brønsted-Lowry acid or as a Brønsted-Lowry base.

- ❑ $H_2O + HCl \longrightarrow H_3O^+ + Cl^-$
- ❑ $H_2O + HCO_3^{-1} \longrightarrow H_2CO_3 + OH^{-1}$
- ❑ $H_2O + NH_3 \longrightarrow NH_4^+ + OH^{-1}$
- ❑ $H_2O + HCO_3^{-1} \longrightarrow H_3O^+ + CO_3^{2-}$

$$N_2O_4(g) \rightleftarrows 2\,NO_2(g) \qquad \Delta H^o = +58\ kJ/mol_{rxn}$$

3. The chemical equation shown above represents the reversible reaction in which $N_2O_4(g)$ is converted into $NO_2(g)$. The value of the equilibrium constant, *K*, for this reaction is equal to 0.005 at 25°C..

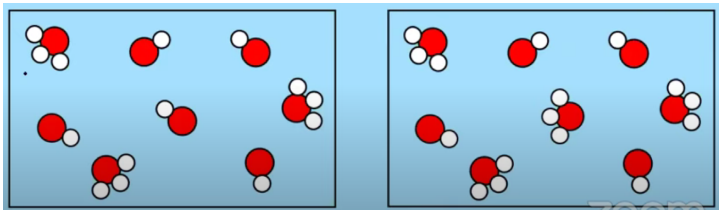
If the temperature of the reaction vessel is increased from 25°C to 100°C, do you predict that the value of *K* will decrease, increase, or remain the same? Justify your answer.

4. A chemist has three different samples of pure water. Each sample is at a different temperature as shown below.

Does each sample have the same pH value? If yes, explain why. If no, explain why not.

If these samples do not have the same pH value, arrange them in order from lowest pH to highest pH.

5. Which of these particle diagrams represents a sample of pure water? How can you tell?



6. Fill in the missing information in the table below. Assume that each solution is at 25°C.

$[H_3O^+]$	pH	$[OH^{-1}]$	pOH
1.0×10^{-9} *M*			
	4.0		

7.

Temperature (°C)	pK_W
10	14.5
25	14.0
30	13.8

Look closely at these pK_W values.

What happens to the value of pK_W as the temperature increases?

What happens to the value of K_W as the temperature increases?

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8. A solution of HI(*aq*) is added to a solution of methylamine, $CH_3NH_2(aq)$. An acid-base reaction takes place. All of the water is removed by evaporation, producing crystals of the ionic compound methylammonium iodide.

(a) In the reaction described above, methylamine and the methylammonium ion represent a conjugate acid-base pair.

(i) Does the methylamine behave as an acid or as a base in this reaction? Justify your answer.

(ii) Write the chemical formula (including the correct charge) for the methylammonium ion.

$$H_2(g) + I_2(g) \rightleftarrows 2\,HI(g)$$

Temperature (K)	Equilibrium Constant, K
298	790
700	55

9. The reaction represented by the balanced equation shown above is an equilibrium system. The value of the equilibrium constant, K, is determined at two different temperatures. The results are shown in the data table above.

(b) Based on the information shown above, is the forward reaction classified as an endothermic process or as an exothermic process? Justify your answer.

8.2 pH and pOH of Strong Acids and Bases

10. If you are given a 0.0025 *M* HCl solution, what is the pH and pOH?

11. If you are given a 0.0015 *M* NaOH solution, what is the pH and pOH?

12. Calculate the pH, $[H_3O^+]$, pOH, and $[OH^-]$ of a 1.25×10^{-5} *M* solution of HBr.

13. Calculate the pH, $[H_3O^+]$, pOH, and $[OH^-]$ of a 3.85×10^{-4} *M* solution of KOH.

$$CH_3CH_2COOH(aq) + H_2O(l) \rightleftarrows CH_3CH_2COO^-(aq) + H_3O^+(aq)$$

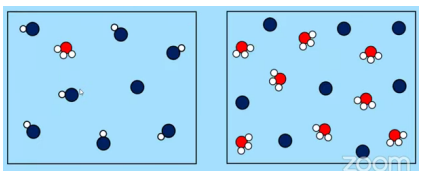
14. Propanoic acid, CH_3CH_2COOH, is a carboxylic acid that reacts with water according to the equation above. At 25°C the pH of a 50.0 mL sample of 0.20 *M* CH_3CH_2COOH is 2.79.

For the following statement ,determine whether the statement is true or false. Explain the reasoning that supports your answer.

"If the pH of a hydrochloric acid solution is the same as the pH of a propanoic acid solution, then the molar concentration of the hydrochloric acid solution must be less than the molar concentration of the propanoic acid solution."

8.3 Weak Acid Base Equilibria

15. Which of the diagrams represents a strong acid, which one represents a weak acid?



Relationship between K_a (or pK_a) and Acid Strength

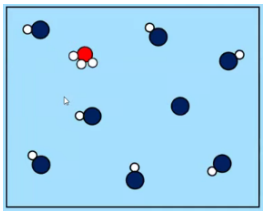
16. $CH_3COOH + H_2O \leftrightarrows H_3O^+ + CH_3COO^-$ $\quad K_a = 1.8 \times 10^{-5}$

$HF + H_2O \leftrightarrows H_3O^+ + F^-$ $\quad K_a = 6.8 \times 10^{-4}$

Two examples of weak monoprotic acids are acetic acid, CH_3COOH, and hydrofluoric acid, HF. There equilibrium dissociations and K_a's are given above. Which of these two weak acids is the stronger acid? How can you tell?

Percent Ionization

17. Based on this particle diagram, what is the percent ionization of this acid?



8.3 Weak Acid Base Equilibria

18. $CH_3COOH + H_2O \leftrightarrows H_3O^+ + CH_3COO^-$

Acetic acid, CH_3COOH, is a weak monoprotic acid that reacts with water according to the equation shown above.
A solution of 0.10 *M* CH_3COOH has a pH of 2.87.

1. Calculate the value of K_a for CH_3COOH.
2. Calculate the percent ionization for 0.10 *M* CH_3COOH.

19. $HOCl + H_2O \leftrightarrows H_3O^+ + ClO^-$

Hypochlorous acid, HClO, is a weak monoprotic acid that reacts with water according to the equation shown above.
The K_a for HOCl is 3.0×10^{-8}.

1. Calculate the pH of a 0.10 *M* HOCl.
2. Calculate the percent ionization for 0.10 *M* HOCl.

20.

21. $(CH_3)_3N + H_2O \leftrightarrows (CH_3)_3NH^+ + OH^-$

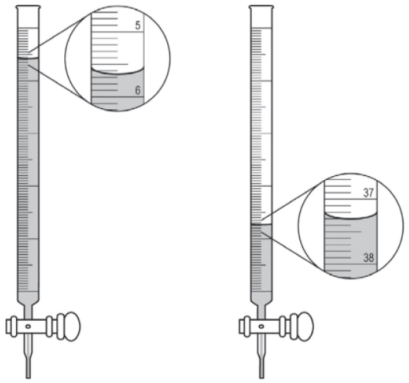
Trimethylamine, $(CH_3)_3N$, is a weak base that reacts with water according to the equation shown above.
The K_b for $(CH_3)_3N$ is 6.4×10^{-5}.

1. Calculate the pH of 0.10 *M* $(CH_3)_3N$.
2. Calculate the percent ionization of 0.10 *M* $(CH_3)_3N$.

AP STYLE FRQ

22. A student is given a 25.0 mL sample of a solution of an unknown monoprotic acid and asked to determine the concentration of the acid by titration. The student uses a standardized solution of 0.110 *M* NaOH(*aq*), a buret, a flask, an appropriate indicator, and other laboratory equipment necessary for the titration.

(a) The images below show the buret before the titration begins (below left) and at the end point (below right). What should the student record as the volume of NaOH(*aq*) delivered to the flask?



(b) Based on the given information and your answer to part (a), determine the value of the concentration of the acid that should be recorded in the student's lab report.

(c) In a second trial, the student accidentally added more NaOH(*aq*) to the flask than was needed to reach the end point, and then recorded the final volume. Would this error increase, decrease, or have no effect on the calculated acid concentration for the second trial? Justify your answer.

$$HF(aq) + H_2O(l) \rightleftarrows F^-(aq) + H_3O^+(aq)$$

23. The ionization of HF(*aq*) in water is represented by the equation above. In a 0.0350 *M* HF(*aq*) solution, the percent ionization of HF is 13.0 percent.

(a) Two particulate representations of the ionization of HF molecules in the 0.0350 *M* HF(*aq*) solution are shown below in Figure 1 and Figure 2. Water molecules are not shown. Explain why the representation of the ionization of HF molecules in water in Figure 1 is more accurate than the representation in Figure 2. (The key below identifies the particles in the representations.)

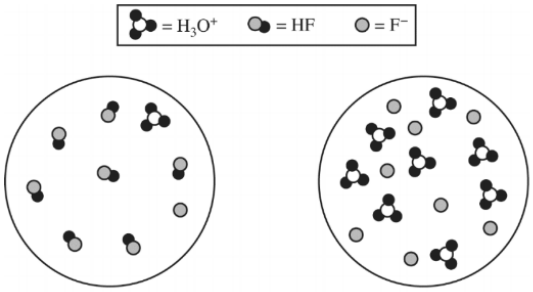


Figure 1 Figure 2

(b) Use the percent ionization data above to calculate the value of K_a for HF.

(c) If 50.0 mL of distilled water is added to 50.0 mL of 0.035 *M* HF(*aq*), will the percent ionization of HF(*aq*) in the solution increase, decrease, or remain the same? Justify your answer with an explanation or calculation.

8.4 Acid-Base Reactions and Buffers

Identifying Strong versus Weak Acids

24. Which of the following are strong acids? Which of the following are weak acids? Label each as such.

- ❑ HCl, hydrochloric acid _____
- ❑ HBr, hydrobromic acid _____
- ❑ $HC_2H_3O_2$, acetic acid _____
- ❑ HNO_2, nitrous acid _____
- ❑ HNO_3, nitric acid _____

Definition of a Buffer and Examples of Buffer Solutions

25. Write in all the conjugate bases of all the conjugate acids in the table below.

Conjugate Acid	Conjugate Base
HCl	
HBr	
HNO_3	
HNO_2	
HOCl	
HCN	
HF	
$HC_2H_3O_2$	

*For a **buffer, you want a WEAK ACID and it's conjugate base.***
Cannot use these three. (Strong Acids)
Not make a good buffer.

Since these five are weak acids, they WOULD make a good buffer solution.

26. We could find the conjugate bases as sodium salts of the conjugate acids:

1.0 *M* HNO_2 and 1.0 *M* $NaNO_2$ 1.0 *M* HOCl and 1.0 M NaOCl 1.0 *M* HCN and 1.0 *M* NaCN 1.0 *M* HF and 1.0 *M* NaF 1.0 *M* $HC_2H_3O_2$ and 1.0 *M* $NaC_2H_3O_2$	**Guiding Questions** (1) What is the pH of each of these buffer solutions? (2) Why do they behave as a good pH buffer solution? How exactly does a buffer work?

27. Complete the table by calculating the pK_a and pH of buffer solutions $pK_a = -\log(K_a)$

Buffer Components	K_a of the Weak Acid	pK_a of the Weak Acid	pH of the Buffer Solution
1.0 *M* HNO_2 and 1.0 *M* $NaNO_2$	4.0×10^{-4}		
1.0 M HOCl and 1.0 M NaOCl	2.9×10^{-8}		
1.0 M HCN and 1.0 M NaCN	6.2×10^{-10}		

Using the Henderson-Hasselbach Equation (or Not)

28. A buffer solution contains 1.2 *M* HNO_2 and 0.80 *M* $NaNO_2$. What is the pH of this buffer solution? ($K_a = 4.0 \times 10^{-4}$)
Solve using the K_a expression AND the Henderson-Hasselbach Equation

29. A buffer solution that contains a mixture of $HC_2H_3O_2$ and $NaC_2H_3O_2$ has a pH of 5.00. If $[HC_2H_3O_2] = 2.0$ *M*, what is the value of the $[C_2H_3O_2^-]$? (K_a for $HC_2H_3O_2 = 1.8 \times 10^{-5}$) **Solve using the K_a expression AND the Henderson-Hasselbach Equation**

30.

Conjugate Acid	K_a	pK_a	Conjugate Base	K_b	pK_b
HNO_2	4.0×10^{-4}	3.40	NO_2^-		
HOCl	2.9×10^{-8}	7.54	ClO^-		
NH_4^+			NH_3	1.8×10^{-5}	4.74
CH_3NH_3			CH_3NH_2	4.4×10^{-4}	3.36

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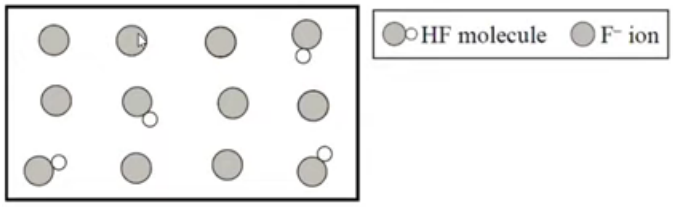
31. Answer the following questions that relates to a buffer solution that contains hydrofluoric acid, HF, and sodium fluoride, NaF. (K_a for HF = 6.8×10^{-4})

(a) The pK_a for HF is equal to 3.17. A diagram shown below is a particulate representation of a buffer solution containing HF and F^-. Based on the information in the diagram, do you predict that the pH of this solution should be less than, equal to, or greater than 3.17? Justify your answer.



(b) A buffer solution is made by mixing equimolar amounts of HF(*aq*) and NaF(*aq*). When a small amount of 12 *M* HNO_3(*aq*) is added to this buffer, the pH of the solution changes from 3.17 to 3.15. Write a balanced net ionic equation that accounts for the fact that the pH does not change significantly when the HNO_3(*aq*) is added to the buffer solution.

(c.) Determine the volume, in mL, of 10.0 *M* NaOH(*aq*) that should be added to 1000 mL of 1.0 *M* HF(*aq*) in order to create a buffer solution that has a pH of 3.17. Justify your answer with calculations.

(d) A buffer has a pH of 3.17 and has the following concentrations.

1.0 *M* HF and 1.0 *M* NaF

32. A solution is prepared combining 500 mL of the buffer described above with 500 mL of distilled water to create a solution with a volume of 1000 mL. Do you predict that the pH of the final solution should be less than, equal to, or greater than 3.17? Justify your answer.

33. Titration Practice

A 25.00mL sample of HNO_2 solution is titrated with 20.50mL of 0.250M NaOH solution to reach the equivalence point.

Write the titration reaction
Write the reactions for Hydrolysis
Calculate the concentration of the original sample

Calculate the pH of the initial sample before any standard is added

Calculate the pH of the solution at the equivalence point

Calculate the pH of the solution if 35.0mL of standard was added to the sample

. Construct a titration curve for your sample. Be sure to include the following:

Title • Labeled axis • Correct scale • Smooth curve • Points plotted

34.

A 20.00mL sample of NH_3 solution is titrated with 25.0mL of 0.250M $HClO_4$ solution to reach the equivalence point

Write the titration reaction
Write the reactions for Hydrolysis
Calculate the concentration of the original sample

Calculate the pH of the initial sample before any standard is added

Calculate the pH of the solution at the equivalence point

Calculate the pH of the solution if 45.0mL of standard was added to the sample

. Construct a titration curve for your sample. Be sure to include the following:

Title • Labeled axis • Correct scale • Smooth curve • Points plotted