Name ______________________________________
Period ___ Date ___/___/___

18 • Reactions between Acids and Bases

ALKA SELTZER™ LABETTE

Equipment:

4 plastic cups	1 Alka Seltzer tablet	glass stir rod
distilled water	1 M HCl	10% vinegar solution
universal indicator	1 M NaOH	

I. pH Change of Distilled Water:

1. Pour distilled water into the four cups until they are about half-filled.
   To each cup add 10 drops of universal indicator. Stir. Set two cups aside for Part II.
   Add a drop of 1 M HCl to one cup. Stir. Can you observe any color (pH) change? Repeat.
   Add a drop of 1 M NaOH to the other cup. Stir. Do you observe any color (pH) change? Repeat.
2. Write your observations about how easily the color changes with added acid or base:

II. pH Change of Alka Seltzer Solution:

3. Break the Alka Seltzer tablet into two halves.
   Add one half to each of the two cups with distilled water and universal indicator.
   Add a drop of 1 M HCl to one cup. Stir. Can you observe any color (pH) change? Repeat.
   Add a drop of 1 M NaOH to the other cup. Stir. Do you observe any color (pH) change? Repeat.
4. Write your observations about how different the Alka Seltzer solution acts compared to water:

III. Why Does This Happen?

Alka Seltzer contains the weak acid, citric acid, which we will write as HA.
The dissociation equilibrium for HA is: $HA \rightleftharpoons H^+ + A^-$

5. HA is a proton ________ (donor / acceptor) A^- is a proton ________ (donor / acceptor)

6. Using Le Châtelier's Principle, indicate the effect of the following changes:

	HA	H^+	A^-
add H^+	___	___	___
add OH^-	___	___	___

7. In Alka Seltzer, the lack of color change is due to the fact that the added H^+ ions are *almost all* used up and the removed H^+ ions are *almost all* replaced.
   Added H^+ ions are almost all *absorbed* by ______.
   H^+ ions (removed by OH^-) are almost all *replaced* by _______.
   The solution contains large numbers of donors (weak acid) and acceptors (conjugate base).

$$\mathbf{HA} \rightleftharpoons H^+ + \mathbf{A^-}$$

8. Solutions with large concentrations of acids (proton donors) and bases (proton acceptors) that do not neutralize each other are called ___________.

IV. Let's Make A Buffer (a.k.a. "Half Titration")

9. We can *make* the conjugate base of a weak acid ($HC_2H_3O_2$) by neutralizing the acid with NaOH. The conjugate base of $HC_2H_3O_2$ is: ____________
10. Write the neutralization equation for $HC_2H_3O_2$ with NaOH. Circle $HC_2H_3O_2$'s conjugate base.

11. Rinse out your four cups. Put diluted vinegar into one cup and split the liquid equally into two cups. Add 10 drops of universal indicator to each cup. Neutralize the acid in one cup by adding 1 M NaOH. When will you know you have added enough NaOH? ____________________
12. In the cup of neutralized acid, essentially all of the $HC_2H_3O_2$ has been changed to __________.
13. Mix the two cups together, pour about ¼ of your mixture into a clean cup (for Part V), and split the remaining liquid evenly between the two cups. What is the color (pH) of the mixture? _____
14. Test the two samples (as you did with the Alka Seltzer) to see if they are a buffer. Write your observations about whether this solution acts as a buffer:

V. Buffering Capacity

Take the small amount of buffer from Step 13 above. Fill the cup almost full with distilled water. Split the solution between the two cups. Add more universal indicator to each cup if needed. Test the two samples (as you did with the Alka Seltzer) to see whether they act as a buffer.

15. Write your observations about the "buffering capacity" of the diluted buffer:

VI. Calculation

16. The equilibrium of a buffer is the same as the equilibrium of the dissociation of an acid. Write the dissociation equation for $HC_2H_3O_2$. $K_a = 1.8 \times 10^{-5}$. Use HAc as an abbreviation.

17. In your mixture (Step 13 above), how does [HAc] compare to $[Ac^-]$? ____________
18. Write the K_a expression for HAc:

19. If $[HAc] = [Ac^-]$, the expression changes to:

20. What is the significance of the pK_a?
21. The pH of this buffer must be _______ (Relate to color observed in Step 13 above.)
22. The most effective buffer is made from large equal concentrations of the acid and its conjugate base. In this case, the pH = pK_a. What is the pH of the best buffer made from the following acids?
    a) HCN $K_a = 4.0 \times 10^{-10}$ The pH of the best buffer is _____.
    b) HF $K_a = 7.2 \times 10^{-4}$ The pH of the best buffer is _____.
    c) HClO $K_a = 3.5 \times 10^{-8}$ The pH of the best buffer is _____.

23. For HAc, the pH of the best buffer is: ______ If you wanted a buffer with a pH of 5.00, however, would you need to add more acid, HAc, or more base, Ac^-? ______
24. Determine the ratio of $[Ac^-]$ to [HAc] that would form a buffer with a pH of 5.00? _______
    Use the Henderson-Hasselbalch equation:

$$pH = pK_a + \log\frac{[A^-]}{[HA]}$$