Ch 18 - Acid-Base Reactions

NChO 1999

38. Which acid, together with its sodium salt, would be best for preparing a buffer with a pH = 4.5?
    (A) HCN ($K_a = 4.9 \times 10^{-10}$)
    (B) $C_3H_5O_2H$ ($K_a = 1.3 \times 10^{-5}$)
    (C) HF ($K_a = 6.8 \times 10^{-4}$)
    (D) $ClC_2H_2O_2H$ ($K_a = 1.4 \times 10^{-3}$)

39. What is the pH of a solution that contains 0.50 M sodium benzoate and 0.75 M benzoic acid? ($K_a = 6.8 \times 10^{-5}$)
    (A) 3.99 (C) 4.57
    (B) 4.34 (D) 5.22

NChO 1998

38. Which of these solutions, appropriately combined, could be used to produce a buffer?
    (A) HCl and NaOH
    (B) HNO_2 and $NaNO_3$
    (C) KI and KOH
    (D) HF and NaOH

NChO 1997

36. Which pair of chemicals would produce a buffer solution when equal numbers of moles of each are mixed?
    (A) HF and NaF (C) HCl and NH_3
    (B) HF and $HC_2H_3O_2$ (D) HNO_2 and NaOH

39. Which titration will have an equivalence point at the lowest pH?
    (A) HCl and KOH (C) HF and NH_3
    (B) HF and NaOH (D) HCl and NH_3

NChO 1995

39. A 0.100 M solution of acetic acid ($K_a = 1.8 \times 10^{-5}$) is titrated with a 0.1000 M solution of NaOH. What is the pH when 50% of the acid has been neutralized?
    (A) 2.38 (C) 5.70
    (B) 4.74 (D) 7.00

44. Which indicator is most appropriate for titrating a 0.100 M solution of NH_3 with 0.100 M HNO_3? The equilibrium constant, K_a, for NH_3 equals 1.8×10^{-5}

Indicator	pH color transition range
(A) cresol red	1-2
(B) methyl red	4-6
(C) phenolphthalein	8-10
(D) alizarin yellow	10-12

NChO 1993

35. When a particular aqueous solution is diluted by a factor of ten with H_2O, the pH increases by one pH unit. This solution most likely contains a
    (A) weak acid (C) strong acid
    (B) strong base (D) buffer

NChO 1992

29. When 50.0 mL of 0.200 M HCl is mixed with 150.0 mL of 0.100 M NaOH, the reaction is as shown.
    $NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l)$
    What is the concentration of the resulting solution?
    (A) 0.0500 M NaCl
    (B) 0.100 M NaCl
    (C) 0.0500 M NaCl and 0.0250 M NaOH
    (D) 0.0500 M NaCl and 0.0500 M NaOH

NChO 1991

26. Which pair constitutes a buffer ?
    (A) HCl and KCl
    (B) NaOH and NaCl
    (C) HNO_2 and $NaNO_2$
    (D) HNO_3 and NH_4NO_3

32. The best acid for preparing a buffer of pH = 3.2 has a K_a near
    (A) 2.0×10^{-5} (C) 3.2×10^{-2}
    (B) 6.0×10^{-4} (D) 4.0×10^{-6}

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Annotated Answers:

1999-38.	**(B) $C_3H_5O_2H$** – The best buffer has a pH = pK_a of the acid. HCN pKa = 9.31; $C_3H_5O_2H$ pKa = 4.89; HF pKa = 3.17; $ClC_2H_2O_2H$ pKa = 2.85
1999-39	**(A) 3.99** Note: benzo**ate ion** is the conjugate base of the acid, benzo**ic acid**.,, just like nitr**ate ion** is the conjugate base of the acid, nitr**ic acid**. If the buffer was 50:50 Acid:Conjugate Base, the pH = pKa = 4.17 You have more of the acid, so the pH will be lower. The only answer less than 4.17 is 3.99.
1998-38.	**(D) HF and NaOH** (A) HCl & NaOH strong acid & strong base will never make a buffer. (B) HNO_2 & $NaNO_3$ this could work if the salt were $NaNO_2$. (C) KI and KOH a salt and a strong base… no buffer here (D) This will form a buffer if you have ***half as much NaOH*** as HF. When you neutralize HF with NaOH, you form F^-, the conjugate base of HF.
1997-36.	**(A) HF and NaF** – classic weak acid (HF) and its conjugate base (F^-) Notice the question states "equal numbers of moles of each". (B) HF and $HC_2H_3O_2$ -- two weak acids (C) HCl and NH_3 -- this would make a buffer if you had **half as much** HCl as NH_3. See above. (D) HNO_2 and NaOH – this would work if you had **half as much NaOH** as HNO_2.
1997-39.	**(D) HCl and NH_3** Notice: "Lowest pH = most acidic" Look for a **strong** acid titrated with a **weak** base.
1995-39.	**(B) 4.74** When the acid has been 50% titrated, you have a buffer where $[HC_2H_3O_2] = [C_2H_3O_2^-]$ and the pH = pKa. $-\log(1.8 \times 10^{-5}) = 4.74$
1995-44.	**(B) methyl red pH color transition range: 4-6** Strong acid + weak base will form an **acidic** solution at the end point of the titration. A 0.100 <u>M</u> solution of HCl would have a pH of 1.00 A solution of NH_4^+ will be much closer to 7. The pH CAN be calculated: Equal volumes of HNO_3 and NH_3 are needed to reach the endpoint. All of the NH_3 is converted to NH_4^+, but the volume is doubled. $[NH_4^+] = 0.100 \div 2 = 0.0500$ <u>M</u>. The question to answer is: What is the pH of a 0.0500 M solution of NH_4^+? Ka of $NH_4^+ = K_w/K_b = 5.56 \times 10^{-10}$ Shortcut: $x = [H^+] = \sqrt{(0.0500)(5.56 \times 10^{-10})} = 5.27 \times 10^{-6}$ pH = 5.28
1993-35.	**(C) strong acid** This is kind of a logic problem using information you know about acids and pH's. When you dilute the substance, the pH increases. Is it an acid? 3→4 or base? 8→9. But you know that diluting an acid or a base would move it closer to 7, so 3→4 makes sense. The fact that diluting it 10x changes the pH by 1 means it must be a strong acid. A weak acid only partially dissociates (breaks up). Diluting it would lower the $[H^+]$, but by 10x.
1992-29.	**(C) 0.0500 M NaCl and 0.0250 M NaOH** First, remember that volume x molarity = moles. You have 0.0100 moles HCl and 0.150 moles NaOH .

	All of the HCl gets used up and 0.0100 moles of NaCl is formed. Divide these moles by the total volume (200 mL or 0.200 L) to get the answer. I did this with an ICE box.
1991-26.	**(C) HNO_2 and $NaNO_2$** Classic buffer. Weak acid (HNO_2) and its conjugate base (NO_2^-). Remember, Na^+ is a spectator ion. (A) HCl and KCl – strong acid and its conjugate base. This is not a buffer (B) NaOH and NaCl -- strong base and its conjugate acid. This is not a buffer (D) HNO_3 and NH_4NO_3 -- strong acid and the conjugate acid of NH_3. This is not a buffer.
1991-32.	**(B) 6.0×10^{-4}** The pH of a buffer is the pKa of the acid. $K_a = 10^{-pKa}$ A K_a with "x 10^{-4}" will result in a pK_a near 3.2.