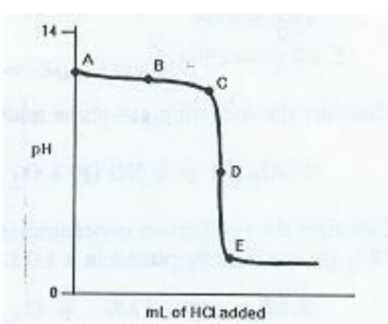
1. Addition of a strong acid to a solution of acetic acid at equilibrium ($HOAc + H_2O <=> H_3O^+ + OAc^-$) would cause the:
   a. acetate ion concentration to decrease.
   b. acetate ion concentration to increase.
   c. pH to increase.
   d. hydroxide ion concentration to increase.
   e. None of the above is correct.
2. Calculate to a first approximation the molar concentration of hydronium ion in a 0.171 M solution of benzoic acid (HOBz, a monoprotic weak acid with $K_a = 6.5 \times 10^{-5}$).
3. Consider the following data for the series of hydrogen halide Bronsted acids,
4. Acid K_a
5. HF 7.2×10^{-4}
6. HCl 1×10^{6}
7. HBr 1×10^{9}
8. HI 3×10^{9}

Which of these Bronsted acids would have the **weakest** conjugate base?

   a. HF
   b. HCl
   c. HBr
   d. HI

9. Shown below is a titration curve for the titration of NH_3 (a weak base) with HCl (a strong acid).



At which point are the amounts of the acid and the base stoichiometrically equivalent?

a. Point A

b. Point B

c. Point C

d. Point D

e. Point E

10. Benzoic acid, $C_6H_5CO_2H$, is a weak acid (K_a = 6.3 x 10^{-5}). Calculate the initial concentration (in M) of benzoic acid that is required to produce an aqueous solution of benzoic acid that has a pH of 2.54.

11. Which of the following weak acid dissociation constants would result in the smallest degree of dissociation?

a. K_a = 1.0 x 10^{-2}

b. K_a = 1.0 x 10^{-3}

c. K_a = 1.0 x 10^{-4}

d. K_a = 1.0 x 10^{-5}

12. Addition of sodium acetate to an acetic acid solution at equilibrium will cause:

a. no change in H_3O^+ concentration.

b. H_3O^+ concentration to decrease.

c. H_3O^+ concentration to increase.

d. concentrations of all species to increase.

e. a decrease in hydroxide concentrations.

13. What is the H_3O^+ concentration in a 0.17 M solution of a weak acid, HA, with a dissociation constant of 3.21 x 10^{-6}.

14. Calculate the pH of an aqueous solution prepared to contain 1.3 x 10^{-3} M sodium nitrite ($NaNO_2$) if the acid dissociation equilibrium constant, K_a, for nitrous acid (HNO_2) is 5.1 x 10^{-4}.

a. 3.1

b. 5.1

c. 7.0

d. 7.3

e. 10.9

15. The very first disinfectant used by Joseph Lister was called "carbolic acid". This substance is now known as phenol (PhOH). What is the H_3O^+ ion concentration in a 0.10 M solution of phenol? [PhOH: $K_a = 1.0 \times 10^{-10}$]

a. 1.0×10^{-11}
b. 3.2×10^{-5}
c. 5.0×10^{-12}
d. 3.2×10^{-6}

16. The sweetener, saccharin, is a weak monoprotic acid with $K_a = 2.1 \times 10^{-12}$. Calculate the H_3O^+ concentration in a solution that contains 1.0×10^{-2} mole of saccharin in 1.00 L of otherwise pure water.

a. 1.4×10^{-7}
b. 1.8×10^{-7}
c. 2.1×10^{-12}
d. 2.1×10^{-14}

17. When would the pH of a solution prepared by adding sodium formate to formic acid be equal to the pK_a of formic acid, HCO_2H?

a. when $[HCO_2H] < [HCO_2^-]$
b. when $[HCO_2H] = [HCO_2^-]$
c. when $[HCO_2H] > [HCO_2^-]$
d. the pH of this buffer will never equal the pK_a of formic acid.

18. Calculate the pH of a buffer prepared by mixing 0.10 mol of sodium formate and 0.05 mol of formic acid in 1.0 L of solution. [HCO_2H: $K_a = 1.8 \times 10^{-4}$]

a. 1.8×10^{-4}
b. 3.44
c. 4.05
d. 5.31
e. none of these

19. Many insects discharge sprays containing weak acids as a means of defense. For example, some ants discharge a spray that contains the weak acid, formic acid (HCO_2H). Calculate the pH of a 0.14 M solution of formic acid. K_a (HCO_2H) $= 1.8 \times 10^{-4}$.

20. Calculate the pH of a solution prepared by dissolving 0.20 moles of benzoic acid (abbreviated HOBz) and 0.15 moles of sodium benzoate (abbreviated NaOBz) in enough water to make 1.0 L of solution. The acid-dissociation equilibrium constant for benzoic acid is $K_a = 6.3 \times 10^{-5}$.

21. Calculate the $[OH^-]$ (in M) for an acetic acid solution ($K_a = 1.8 \times 10^{-5}$) having a pH of 6.32.

22. Ascorbic acid is also known as Vitamin C. In a 0.10 M solution of ascorbic acid 2.8% of the ascorbic acid will dissociate. Consider the pH you would measure for a 0.25 M solution of ascorbic acid. Which of the following statements is true?

   a. The pH would show that the %-dissociation would be the same in both ascorbic acid solutions.
   b. The pH would show that the %-dissociation would be twice as much in the more concentrated acid solutions.
   c. The pH of the more concentrated solution would be lower.
   d. You must know the K_a value for ascorbic acid before determining which of the above selections is true.

23. A buffer can be prepared by mixing:

   a. a strong acid and its conjugate base.
   b. a strong base and its conjugate acid.
   c. a weak acid and its conjugate base.
   d. a weak acid and a strong acid.
   e. all responses above are correct.

24. Calculate the pH of a solution containing 0.1 M formic acid (a monoprotic weak acid with $K_a = 1.8 \times 10^{-4}$) and 0.1 M sodium formate.

25. Calculate the molar hydronium ion concentration, $[H_3O^+]$, in a 2.0×10^{-3} M solution of hypoiodious acid (HOI, $K_a = 2.3 \times 10^{-11}$).

26. Which of the following solutions would be best to buffer a solution near pH = 4 ($[H_3O^+] = 1.0 \times 10^{-4}$).

   a. 1.0×10^{-4} M HCl
   b. 1.0×10^{-4} M NaOH

c. A solution containing approximately equal concentrations of formic acid (K_a = 1.8 x 10^{-4}) and sodium formate.

d. A solution containing approximately equal concentrations of hypochlorous acid (HOCl, K_a = 2.9 x 10^{-8}) and sodium hypochlorite (NaOCl).

e. A solution containing approximately equal concentrations of ammonia (K_b = 1.8 x 10^{-5}) and ammonium chloride.

27. Which of the following solutions would be an acid/base buffer?

a. 0.1 M HCl, a strong acid

b. 0.1 M acetic acid, a weak acid

c. 0.1 M sodium acetate

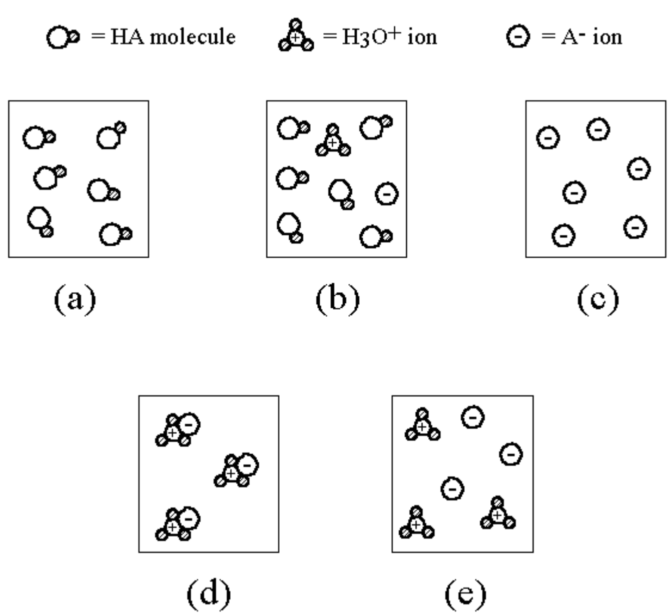
d. 0.1 M acetic acid plus 0.1 M sodium acetate

e. pure water

28. Which of the following diagrams represents a snapshot of a very small portion of a beaker containing a weak acid, HA, dissolved in water?

HA (l) + H_2O (l) <=> H_3O^+ (aq) + A^- (aq)

Note that the solvent molecules (i.e., H_2O) are not shown for clarity.



29. Consider the following monoprotic acids,

I. Acetic acid, CH_3COOH, $K_a = 1.8 \times 10^{-5}$

II. Formic acid, HCO_2H, $K_a = 1.8 \times 10^{-4}$

III. Hypobromous acid, HOBr, $K_a = 2.4 \times 10^{-9}$

IV. Nitrous acid, HNO_2, $K_a = 5.1 \times 10^{-4}$

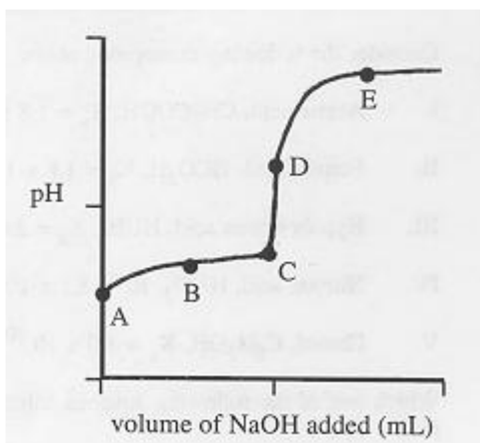
V. Phenol, C_6H_5OH, $K_a = 1.0 \times 10^{-10}$

Which one of the following aqueous solutions will have the **HIGHEST** pH?

a. 0.10 M CH_3COONa
b. 0.10 M HCO_2Na
c. 0.10 M NaOBr
d. 0.10 M $NaNO_2$
e. 0.10 M C_6H_5ONa

30. Calculate the mass (in g) of sodium acetate (CH_3COONa, MW = 82.04) that would need to be added to 1.0 L of 0.15 M acetic acid (CH_3COOH, MW = 60.05, $K_a = 1.8 \times 10^{-5}$) in order to prepare a buffer solution with a pH of 5.12.

31. The titration curve for a weak acid, HA, is shown below.



At which point in the titration is the concentration of the weak acid, HA, equal to the concentration of its conjugate base, A^-?

a. Point A
b. Point B
c. Point C

d. Point D

e. Point E

32. Which of the following mixtures would make the best buffer?

a. CH_3CO_2H and NH_4Cl

b. HCl and NaOH

c. CH_3CO_2Na and NH_3

d. CH_3CO_2Na and NH_4Cl

e. NH_3 and NH_4Cl

33. Which of the following statements concerning buffer solutions *is not* correct?

a. Buffer solutions have a pH unaffected by the addition of small amounts of a strong acid.

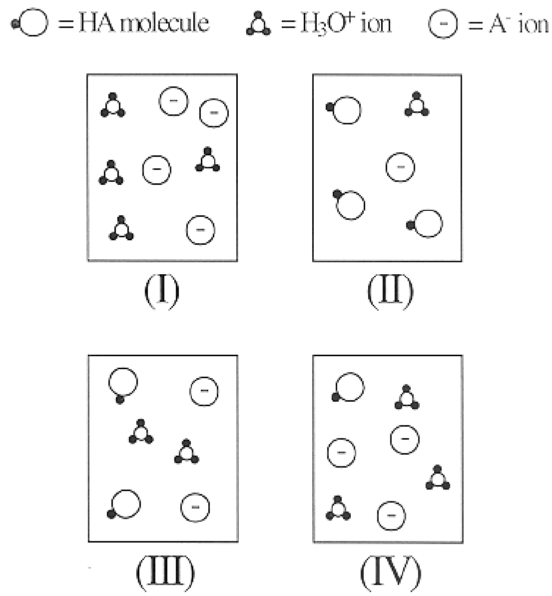
b. Buffer solutions are formed by mixing equal concentrations of a weak acid and the salt of its conjugate base.

c. Buffer solutions are formed by mixing equal concentrations of a weak base and the salt of its conjugate acid.

d. Buffer solutions include a solution of 0.10 M HCl mixed with equal amounts of 0.10 M NaOH solution.

34. Calculate the pH of a solution prepared by dissolving 0.075 mol of soluble sodium nitrite in 300 mL of 0.25 M nitrous acid. (HNO_2: $K_a = 5.10 \times 10^{-4}$).

35. What are the relative strengths of the acids in the vessels shown below? *Note: (1) each vessel has the same volume and (2) H_2O molecules are not shown for clarity.*



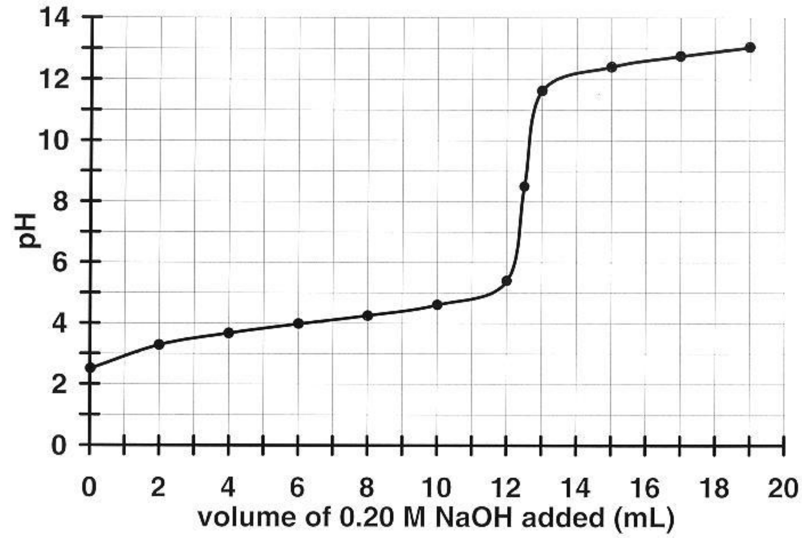
a. IV > I > III > II
b. I > II > III > IV
c. III > IV > I > II
d. II > III > IV > I
e. I > IV > III > II

36. Penicillin G (HPG) is a weak acid (K_a = 1.74 x 10^{-3}). Calculate the pH of a 0.20 M aqueous solution of sodium penicillin G (NaPG).

USE THE TITRATION CURVE BELOW FOR A WEAK, MONOPROTIC ACID TO ANSWER THE NEXT TWO QUESTIONS.

37. If the titration curve was obtained by titrating a 25.00-mL sample of the weak acid, what is the molar concentration of the weak acid in the solution?

38. What is the pK_a of the weak acid?



39. Calculate $[OH^-]$ (in M) for an acetic acid solution ($K_a = 1.8 \times 10^{-5}$) having a pH = 4.32.

40. Calculate the pH of a 0.35 M aqueous solution of hydrofluoric acid, HF. For HF, $K_a = 7.2 \times 10^{-4}$.

41. When the salt of a weak acid (e.g., sodium formate) is added to a solution of a weak acid (e.g., formic acid) at equilibrium, the:

a. hydronium ion concentration will remain unchanged.
b. hydronium ion concentration will increase.
c. hydronium ion concentration will decrease.
d. hydroxide ion concentration will decrease.
e. hydronium ion and hydroxide ion concentrations will both decrease.

42. Calculate the pH of a 5.2×10^{-2} M solution of benzoic acid ($K_a = 6.5 \times 10^{-5}$) in otherwise pure water.

43. Which of the following solutions would be the best pH buffer?

a. 0.001 M HCl
b. 0.001 M acetic acid
c. 0.1 M acetic acid/0.1 M sodium acetate
d. 0.1 M acetic acid/0.1 M HCl

44. Consider the following data for the series of hydrogen halide Bronsted acids,

45. Acid K_a

46.

47. HF 7.2×10^{-4}

48. HCl 1×10^{6}

49. HBr 1×10^{9}

50. HI 3×10^{9}

Which of these Bronsted acids would have the **STRONGEST** conjugate base?

a. HF
b. HCl
c. HBr
d. HI

51. The addition of small amounts of either acid or base to a buffer solution causes only small changes in pH because the buffer solution:

a. does not contain either H_3O^+ or OH^-.
b. contains large amounts of both H_3O^+ and OH^-.
c. reacts with the added acid or base.
d. contains a strong acid and the salt of the strong acid.
e. contains a strong base and the salt of the strong base.

52. Consider the following monoprotic acids,

I. Acetic acid, CH_3COOH, $K_a = 1.8 \times 10^{-5}$
II. Formic acid, HCO_2H, $K_a = 1.8 \times 10^{-4}$
III. Hypobromous acid, HOBr, $K_a = 2.4 \times 10^{-9}$
IV. Nitrous acid, HNO_2, $K_a = 5.1 \times 10^{-4}$
V. Phenol, C_6H_5OH, $K_a = 1.0 \times 10^{-10}$

Which of the following aqueous solutions will have the **LOWEST** pH?

f. 0.10 M CH_3COONa
g. 0.10 M HCO_2Na
h. 0.10 M NaOBr
i. 0.10 M $NaNO_2$
j. 0.10 M C_6H_5ONa

53. A pH 2 buffer solution is to be prepared using equal concentrations of a weak acid and the salt of the weak acid. Which of the following acids (and its salt) would be the best choice to prepare the buffer solution?

	acid	**K_a**
(a)	acetic acid (CH_3CO_2H)	1.8×10^{-5}
(b)	benzoic acid ($C_6H_5CO_2H$)	6.4×10^{-5}
(c)	formic acid (HCO_2H)	1.8×10^{-4}
(d)	chlorous acid ($HClO_2$)	1.1×10^{-2}
(e)	None of these. A weak base and the salt of the weak base are required to prepare this solution.	