

CHEMISTRY 204
Hour Exam II
March 14, 2019
Dr. D. DeCoste

Name **KEY**

Signature _____

T.A. _____

Section _____

This exam contains 23 questions on 10 numbered pages. Check now to make sure you have a complete exam. You have two hours to complete the exam. Determine the **best** answer to the first 20 questions and enter these on the special answer sheet. Also, circle your responses in this exam booklet. **Show all of your work and provide complete answers to questions 21, 22 and 23.**

1-20	(60 pts.)	_____
21	(20 pts.)	_____
22	(20 pts)	_____
23	(20 pts.)	_____
Total	(120 pts)	_____

Useful Information:

- Unless otherwise noted, all solutions referred to on this exam are aqueous solutions at 25°C.
- On this exam, H₃O⁺ and H⁺ are used interchangeably.

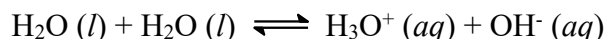
$$K_w = [\text{H}^+][\text{OH}^-] = 1.0 \times 10^{-14} \text{ at } 25^\circ\text{C}.$$

$$\text{For } ax^2 + bx + c = 0, x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

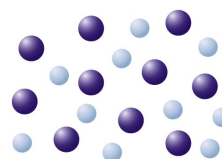
$$\text{pH} = -\log[\text{H}^+]$$

$$K_a = \frac{[\text{H}^+]^2 - K_w}{[\text{HA}]_o - \frac{[\text{H}^+]^2 - K_w}{[\text{H}^+]}}$$

1. The pH of a 0.50M solution of a weak base is 9.87. Calculate the value of K_b for this base.
- a) 1.5×10^{-4} b) 7.4×10^{-5} **c) 1.1×10^{-8}** d) 2.7×10^{-10} e) 3.6×10^{-20}
2. The autoionization of water, as represented by the equation below, is known to be endothermic. Which of the following correctly states what occurs as the temperature of water is **lowered**?



- a) The pH of the water does not change, and the water remains neutral.
 b) The pH of the water decreases, and the water becomes more acidic.
 c) The pH of the water decreases, and the water remains neutral.
 d) The pH of the water increases, and the water becomes more basic.
e) The pH of the water increases and the water remains neutral.
3. You are tutoring students about acid-base chemistry and tell them to visualize what the solution looks like and perhaps draw pictures of the solutions. For example, if you wanted to show a neutral solution with hydrogen ions (H^+ , small circles) and hydroxide ions (OH^- , larger circles), you could draw something like this:



This is neutral because the $[\text{H}^+] = [\text{OH}^-]$. What about for a solution with a pH of 3.14? For every one hydroxide ion you would draw, **about** how many hydrogen ions would you have to draw?

- a) ~3 b) ~1380 c) ~2900 **d) ~52 million** e) $\sim 7.2 \times 10^{10}$
4. Hydrogen cyanide (HCN), while extremely poisonous, is found in apple seeds. If you isolate the HCN from about a pound of apple seeds and dissolve it in water, you can get a 0.10M solution of hydrocyanic acid $[\text{HCN}(aq), K_a = 6.2 \times 10^{-10}]$. Suppose you add 0.0001 moles of HCl to 1.0L of a 0.10M aqueous solution of HCN. Determine the pH of the resulting solution. Assume no volume change upon addition of HCl.
- a) 3.96 **b) 4.00** c) 5.10 d) 6.21 e) 9.40
5. In lecture demonstrations we often used 3.00M acetic acid solution ($\text{HC}_2\text{H}_3\text{O}_2, K_a = 1.8 \times 10^{-5}$). What initial concentration of HF ($K_a = 7.2 \times 10^{-4}$) has the same pH as 3.00M acetic acid?
- a) 0.025M b) 0.075M **c) 0.082M** d) 3.00M e) 4.17M
6. For which 0.010 M diprotic acid would the second dissociation affect the pH significantly?
- a) $\text{H}_2\text{A}; K_{a1} = 1.8 \times 10^{-3}, K_{a2} = 9.3 \times 10^{-4}$**
 b) $\text{H}_2\text{B}; K_{a1} = 2.4 \times 10^{-4}, K_{a2} = 6.1 \times 10^{-8}$
 c) $\text{H}_2\text{C}; K_{a1} = 1.3 \times 10^{-4}, K_{a2} = 5.2 \times 10^{-9}$
 d) $\text{H}_2\text{D}; K_{a1} = 4.2 \times 10^{-2}, K_{a2} = 1.8 \times 10^{-7}$
 e) The second dissociation **never** affects the pH significantly.

7. How many of the following mixtures would result in a buffered solution?

- I. Mixing 100.0 mL of 0.100 M HCl with 100.0 mL of 0.100 M NaOH.
II. Mixing 100.0 mL of 0.100 M NH_3 ($K_b = 1.8 \times 10^{-5}$) with 100.0 mL of 0.100 M NaOH.
III. Mixing 100.0 mL of 0.100 M HCl with 100.0 mL of 0.100 M NH_3 ($K_b = 1.8 \times 10^{-5}$).
IV. Mixing 50.0 mL of 0.100 M HCl with 100.0 mL of 0.100 M NH_3 ($K_b = 1.8 \times 10^{-5}$).

- a) 0 b) 1 c) 2 d) 3 e) 4

8. Consider a 1.00 L aqueous solution to which has been added 1.00 mole of each of the following: HCl, HF ($K_a = 7.2 \times 10^{-4}$), NaCl, NaF, and KOH. How many of the following statements are true about the solution at equilibrium?

- I. $[\text{H}^+] > [\text{OH}^-]$
II. The species with the highest concentration is Cl^- .
III. $[\text{HF}] > [\text{F}^-]$
IV. $[\text{HF}] > [\text{H}^+]$

- a) 0 b) 1 c) 2 d) 3 e) 4

9-11. A 0.250-g sample of a weak diprotic acid is dissolved in 10.0 mL of water and titrated with 0.100M NaOH. The following data are collected:

- After 3.00 mL of 0.100M NaOH are added, the pH is 4.99.
- The first equivalence point is reached after a total of 20.00 mL of 0.100M NaOH are added.
- After a total of 30.00 mL of 0.100M NaOH are added, the pH is 9.64.

9. Determine the molar mass of the acid.

- a) 62.5 g/mol b) 83.3 g/mol c) 109 g/mol d) 125 g/mol e) 833 g/mol

10. Determine the value of K_{a1} for the acid.

- a) 1.0×10^{-5} b) 1.8×10^{-6} c) 6.2×10^{-8} d) 6.2×10^{-10} e) 8.0×10^{-10}

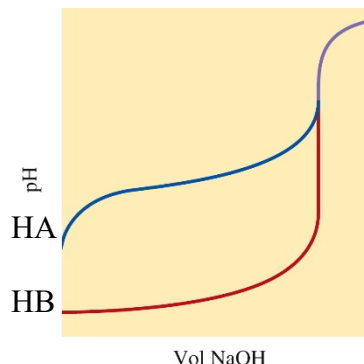
11. Determine the value of K_{a2} for the acid.

- a) 2.3×10^{-10} b) 8.0×10^{-10} c) 6.6×10^{-11} d) 8.5×10^{-11} e) 2.9×10^{-14}

12. A 3.0×10^{-4} -mol sample of Na_2SO_4 is added to 1.0 L of each of two solutions. One solution contains 2.5×10^{-6} M $\text{Ba}(\text{NO}_3)_2$; the other contains 2.5×10^{-3} M $\text{Ca}(\text{NO}_3)_2$. Given that K_{sp} for $\text{BaSO}_4 = 1.5 \times 10^{-9}$ and K_{sp} for $\text{CaSO}_4 = 6.1 \times 10^{-5}$:

- a) Neither BaSO_4 nor CaSO_4 would precipitate.
b) Both BaSO_4 and CaSO_4 would precipitate.
c) BaSO_4 would precipitate but CaSO_4 would not.
d) CaSO_4 would precipitate but BaSO_4 would not.
e) Not enough information is given to determine if precipitation would occur.

- 13, 14. You have 100.0-mL samples of two acids, HA and HB, in separate beakers. You titrate each of these with 0.10M NaOH and generate the following two pH curves:



13. Which of the following best describes the acids?

- a) HA is a weak acid and HB is a strong acid.
 b) HA is a strong acid and HB is a weak acid.
 c) HA and HB are both strong acids.
 d) HA and HB are both weak acids.
 e) We do not get any information about the relative strengths of the acids from these curves.

14. How many of the following statements can we say are true given the pH curves above?

- I. The initial concentrations of the acids (before the titration) were the same.
 II. The equivalence points of the titrations are at the same volume of NaOH added.
 III. The pH values of the solutions at the equivalence points are the same.
 IV. Both beakers contain a buffered solution at some point in the titration.

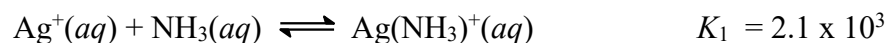
- a) 0 b) 1 c) 2 d) 3 e) 4

- 15, 16. Consider the ionic solid AgCl, for which $K_{sp} = 1.6 \times 10^{-10}$.

15. Calculate the solubility of AgCl(s) in pure water.

- a) $5.4 \times 10^{-4} M$ b) $7.4 \times 10^{-4} M$ c) $1.3 \times 10^{-5} M$ d) $6.3 \times 10^{-5} M$ e) $1.6 \times 10^{-10} M$

16. Silver ions in solution can react with $NH_3(aq)$ as follows:



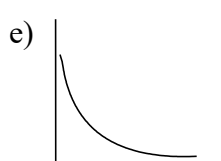
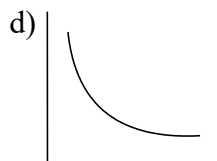
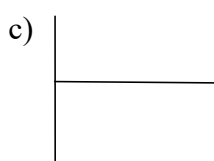
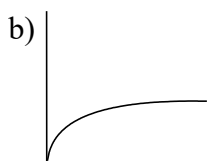
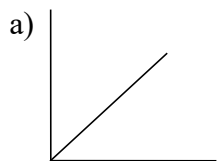
Calculate the solubility of AgCl(s) in 10.0 M $NH_3(aq)$.

- a) $1.6 \times 10^{-10} M$ b) $1.3 \times 10^{-5} M$ c) $6.3 \times 10^{-5} M$ d) $2.8 \times 10^{-3} M$ e) 0.48M

17. The salts AgX, AgY, and AgZ are all essentially equally soluble in water (and none are very soluble at all). When each salt is added to separate beakers of 100 mL of 1.0 M HNO₃, you notice that AgY and AgZ are more soluble in acid than in water, and AgY is much more soluble than AgZ in acid. The salt AgX is no more soluble in strong acid than it is in water. Which of the following best lists the respective K_a values for the acids HX, HY, and HZ?

	K_a for HX	K_a for HY	K_a for HZ
a)	1.0×10^{-4}	1.0×10^{-8}	1.0×10^{-11}
b)	1.0×10^{-11}	1.0×10^{-8}	1.0×10^{-4}
c)	v. large	1.0×10^{-4}	1.0×10^{-8}
d)	1.0×10^{-8}	1.0×10^{-4}	v. large
e)	v. large	1.0×10^{-8}	1.0×10^{-4}

- 18-20. Indicate which of the graphs below best represents each plot described. **Note: a particular graph may NOT be used more than once.**



18. Percent dissociation (y) vs. [HA]_o (initial concentration) (x) for an aqueous weak acid at constant temperature. E
19. K_a (y) vs. K_b (x) for a series of aqueous conjugate acid-base pairs (constant T). D
20. Solubility (y) vs. K_{sp} (x) for a series of ionic solids with the formula MX in pure water at constant temperature. B