

Rules for this exam:

1. Do not open this exam book until told to do so by the instructor.
2. Sit in your assigned seat. You must remain in your seat until the end of the exam. If you finish early, you may not leave or take a book out.
3. This is a closed book exam.
4. Circle the one correct answer.
5. You may use a calculator, but not a PDA or laptop. You may not have a connection open to the internet or to a phone.
6. You may not have any extra sheets of paper out.
7. Place all books, packs, purses, etc. underneath your seat.
8. Be sure to put your name on every sheet of paper. You will not be permitted to do this after the exam ends.
9. This exam ends promptly at the end of the class period. Please put down your pencil when the bell rings and pass your exam to the outside isle.
10. This exam has 25 questions. All count equally. A periodic table and 2 blank sheets are attached to the exam.
11. Do not talk to any other student for any reason. If you have a question, raise your hand and a TA will come to you.

Please sign below to indicate that you understand these rules and that you arrived at your answers without help.

Signed _____ Date _____

For the reaction $j A + k B = l C + m D$, $K_p = K_c (RT)^{\Delta n}$
Where Δn is the sum of coefficients of the gaseous products minus the sum of coefficients of the gaseous reactants.

The roots of a quadratic: $\frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

$\text{pH} = -\log_{10}([\text{H}^+])$; $\text{pOH} = -\log_{10}([\text{OH}^-])$;

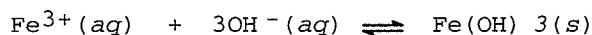
$$\text{pH} = \text{p}K_a + \log\left(\frac{[\text{base}]}{[\text{acid}]}\right)$$

$R = .08206 \text{ L atm}/(\text{mol K})$; $T(\text{K}) = T(^{\circ}\text{C}) + 273.15$

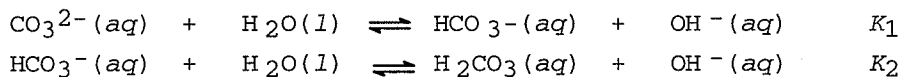
$1 \text{ atm} = 760 \text{ torr} = 101.35 \text{ kPa}$

$$[\text{H}^+]^3 + K_a[\text{H}^+]^2 - (K_w + K_a[\text{HA}]_0)[\text{H}^+] - K_aK_w = 0$$

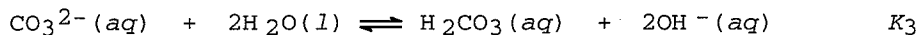
1. The reaction quotient, Q_c , for a reaction has a value of 75 while the equilibrium constant, K_c , has a value of 195. Which of the following statements is accurate?
- A. The reaction must proceed to the left to establish equilibrium.
 - B. The reaction must proceed to the right to establish equilibrium.
 - C. The concentrations of the products will be much smaller than the concentrations of the reactants when the system is at equilibrium.
 - D. The concentrations of the products will be about the same as the concentrations of the reactants when the system is at equilibrium.
2. Write the mass-action expression, Q_c , for the following chemical reaction.



- A. $\frac{[\text{Fe}(\text{OH})_3]}{[\text{Fe}^{3+}][\text{OH}^{-}]^3}$ B. $\frac{[\text{Fe}^{3+}][\text{OH}^{-}]^3}{[\text{Fe}(\text{OH})_3]}$
- C. $\frac{1}{[\text{Fe}^{3+}][\text{OH}^{-}]^3}$ D. $[\text{Fe}^{3+}][\text{OH}^{-}]^3$
3. About half of the sodium carbonate produced is used in making glass products because it lowers the melting point of sand, the major component of glass. When sodium carbonate is added to water it hydrolyses according to the following reactions.



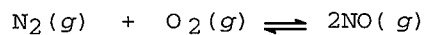
These can be combined to yield



What is the value of K_3 ?

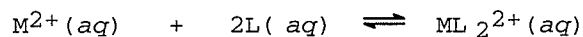
- A. $K_1 \times K_2$ B. K_1 / K_2
- C. $K_1 + K_2$ D. $K_1 - K_2$

4. The reaction of nitrogen with oxygen to form nitric oxide can be represented by the following equation.



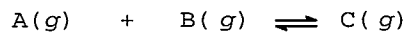
At 2000°C, the equilibrium constant, K_C , has a value of 4.10×10^{-4} . What is the value of K_P ?

- A. 2.17×10^{-8} B. 4.10×10^{-4}
C. 7.65×10^{-2} D. 7.75
5. 10.0 mL of a 0.100 mol L⁻¹ solution of a metal ion M²⁺ is mixed with 10.0 mL of a 0.100 mol L⁻¹ solution of a substance L. The following equilibrium is established:



At equilibrium the concentration of L is found to be 0.0100 mol L⁻¹. What is the equilibrium concentration of ML₂²⁺, in mol L⁻¹?

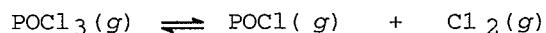
- A. 0.100 B. 0.050 C. 0.025 D. 0.0200 E. 0.0100
6. The equilibrium constant K_C for the reaction



is 0.75 at 150°C. If 0.800 mol of A is added to 0.600 mol of B in a 1.00-L container at 150°C, what will be the equilibrium concentration of C?

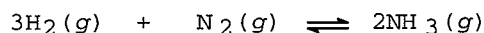
- A. 0.19 M B. 0.36 M C. 0.41 M D. 0.61 M

7. The reaction system

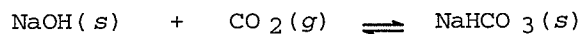


is at equilibrium. Which of the following statements describes the behavior of the system if POCl is added to the container?

- A. The forward reaction will proceed to establish equilibrium.
 - B. The reverse reaction will proceed to establish equilibrium.
 - C. The partial pressures of POCl₃ and POCl will remain steady while the partial pressure of chlorine increases.
 - D. The partial pressure of chlorine remains steady while the partial pressures of POCl₃ and POCl increase.
8. A container was charged with hydrogen, nitrogen, and ammonia gases at 120°C and the system was allowed to reach equilibrium. What will happen if the volume of the container is increased at constant temperature?



- A. There will be no effect.
 - B. More ammonia will be produced at the expense of hydrogen and nitrogen.
 - C. Hydrogen and nitrogen will be produced at the expense of ammonia.
 - D. The equilibrium constant will increase.
9. The following reaction is at equilibrium at one atmosphere, in a closed container.



Which, if any, of the following actions will decrease the total amount of CO₂ gas present at equilibrium?

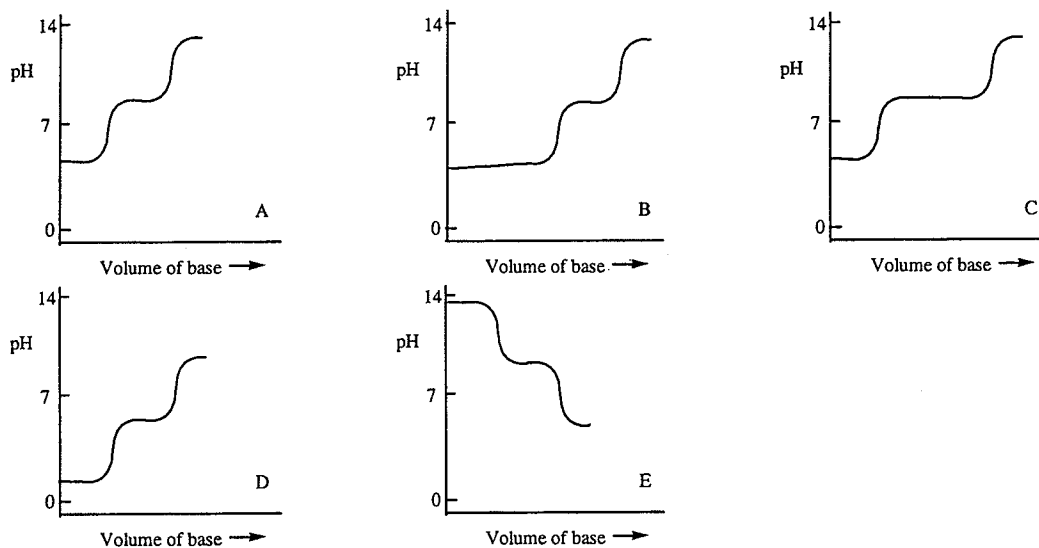
- A. adding N₂ gas to double the pressure
- B. adding more solid NaOH
- C. decreasing the volume of the container
- D. removing half of the solid NaHCO₃
- E. none of the above

10. Which one of the following is a strong acid?
- A. H_2CO_3
 - B. H_2SO_3
 - C. H_2SO_4
 - D. H_3PO_4
 - E. CH_3COOH
11. Which of the following acids has the lowest pH?
- 0.1 M HBO, $\text{pK}_a = 2.43$
0.1 M HA, $\text{pK}_a = 4.55$
0.1 M HMO, $\text{pK}_a = 8.23$
0.1 M HST, $\text{pK}_a = 11.89$
- A. HA
 - B. HST
 - C. HMO
 - D. HBO
12. What is the pH of a 0.050 M LiOH solution?
- A. 1.30
 - B. 3.00
 - C. 11.00
 - D. 12.70
13. Select the pair of substances in which an acid is listed followed by its conjugate base.
- A. NH_3 , NH_4^+
 - B. HPO_4^{2-} , H_2PO_4^-
 - C. HCO_3^- , CO_3^{2-}
 - D. CH_3COOH , $\text{CH}_3\text{COOH}_2^+$
14. A 0.15 M solution of chloroacetic acid has a pH of 1.86. What is the value of K_a for this acid?
- A. 0.16
 - B. 0.099
 - C. 0.0014
 - D. 0.00027

15. What is the pH of a 0.050 M triethylamine, $(\text{C}_2\text{H}_5)_3\text{N}$, solution?
 $K_b = 5.3 \times 10^{-4}$
- A. 2.31 B. 5.32 C. 8.68 D. 11.69
16. A solution is prepared by adding 0.10 mol of potassium acetate, KCH_3COO , to 1.00 L of water. Which statement about the solution is correct?
- A. The solution is basic.
B. The solution is neutral.
C. The solution is acidic.
D. The values for K_a and K_b for the species in solution must be known before a prediction can be made.
17. Which one of the following substances will give an aqueous solution of $\text{pH} < 7$?
- A. KI
B. NH_4Br
C. Na_2CO_3
D. CH_3COONa
E. CH_3OH
18. Citric acid has an acid dissociation constant of 8.4×10^{-4} . It would be most effective for preparation of a buffer with a pH of
- A. 2 B. 5 C. 4 D. 3

19. A buffer is prepared by adding 100 mL of 0.2 M hydrochloric acid to 100 mL of 0.4 M sodium formate. What is the pH of the buffer?
- A. The pH will be greater than the pK_a of formic acid.
 - B. The pH will be less than the pK_a of formic acid.
 - C. The pH will be equal to the pK_a of formic acid.
 - D. The pH will equal the pK_b of sodium formate.
20. A buffer is prepared by adding 300.0 mL of 2.0 M NaOH to 500.0 mL of 2.0 M CH_3COOH . What is the pH of this buffer? $K_a = 1.8 \times 10^{-5}$
- A. 4.57 B. 4.52 C. 4.97 D. 4.92
21. A 50.0-mL sample of 0.50 M HCl is titrated with 0.50 M NaOH. What is the pH of the solution after 28.0 mL of NaOH have been added to the acid?
- A. 0.85 B. 0.75 C. 0.66 D. 0.49

22. Which one of the following is the best representation of the titration curve which will be obtained in the titration of a weak diprotic acid H_2A (0.10 mol L^{-1}) with a strong base of the same concentration?



- A. a B. b C. c D. d E. e

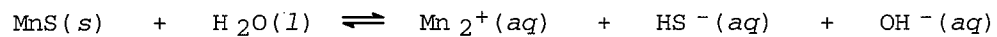
23. Write the ion product expression for silver sulfide, Ag_2S .

- A. $[Ag^+][S^{2-}]$ B. $[Ag^+][S^{2-}]^2$
 C. $[Ag^+]^2[S^{2-}]$ D. $\frac{[Ag^+]^2[S^{2-}]}{[Ag_2S]}$

24. A lab technician adds 0.015 mol of KOH to 1.00 L of 0.0010 M $Ca(NO_3)_2$. $K_{sp} = 6.5 \times 10^{-6}$ for $Ca(OH)_2$. Which of the following statements is correct?

- A. Calcium hydroxide precipitates until the solution is saturated.
 B. The solution is unsaturated and no precipitate forms.
 C. The concentration of calcium ions is reduced by the addition of the hydroxide ions.
 D. One must know K_{sp} for calcium nitrate to make meaningful predictions on this system.

25. Consider the dissolution of MnS in water ($K_{sp} = 3.0 \times 10^{-14}$).



How is the solubility of manganese(II) sulfide affected by the addition of aqueous potassium hydroxide to the system?

- A. the solubility will be unchanged
- B. the solubility will decrease
- C. the solubility will increase
- D. the amount of KOH added must be known before its effect can be predicted