

Name _____

General instructions:

1. Don't panic! Check your answer and see if it makes sense! Some questions are easier than others, so make sure you look all the questions over.
2. **Remember the honor system.** No notes, books, stored information in calculators, or external help is allowed.
3. Use the space provided for answers. The back of pages can be used as scrap paper. **Show work for partial credit!** Write legibly!
4. Questions are numbered and parts of questions are lettered. Numbers in parentheses indicated the point value of the question/part. If you can not get an answer to a prior part of a question, make up a number and carry on with it. You will not be penalized twice for an incorrect answer.
5. Use significant figures where appropriate.
6. This exam has 10 pages, 10 questions, and 120 total points. If you are missing a page, now would be a good time to tell me about it.

Some useful information:

$$0 \text{ K} = -273.2 \text{ }^{\circ}\text{C}$$

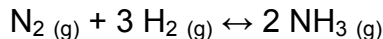
$$1 \text{ atm} = 760 \text{ torr (mm Hg)}$$

Avogadro's number	N	$6.02214 \times 10^{23} \text{ mol}^{-1}$
Gas constant	R	$0.08206 \text{ L atm K}^{-1} \text{ mol}^{-1}$

Acid	K_a
H_3PO_4 (1)	7.5×10^{-3}
HF	7.2×10^{-4}
HNO_2	4.0×10^{-4}
$\text{HC}_2\text{H}_3\text{O}_2$	1.8×10^{-5}
H_2CO_3 (1)	4.3×10^{-7}
H_3PO_4 (2)	6.2×10^{-8}
HCN	6.2×10^{-10}
NH_4^+	5.6×10^{-10}
H_2CO_3 (2)	5.6×10^{-11}
H_3PO_4 (3)	4.8×10^{-13}

Note: The symbol \leftrightarrow is used for the equilibrium symbol on this exam.

1. (12) Circle the correct answer concerning the following **exothermic** reaction.



a) Following addition of H_2 gas at constant T and V the equilibrium position will:

- a) shift to the right
- b) shift to the left
- c) stay the same
- d) can not be determined with the given information

b) Following addition of the inert gas Ne at constant T and V the equilibrium position will:

- a) shift to the right
- b) shift to the left
- c) stay the same
- d) can not be determined with the given information

c) Following addition of the inert gas Ne at constant T and P the equilibrium position will:

- a) shift to the right
- b) shift to the left
- c) stay the same
- d) can not be determined with the given information

d) Following addition of NH_3 gas at constant T and V the:

- a) equilibrium position will shift to the right
- b) equilibrium position will shift to the left
- c) value of K_p for the reaction will increase
- d) value of K_p for the reaction will decrease
- e) b and d

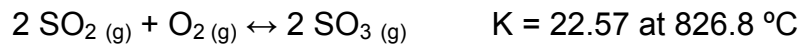
e) Increasing the temperature while keeping the volume constant will:

- a) shift the equilibrium position to the right
- b) shift the equilibrium position to the left
- c) not affect the equilibrium position
- d) can not be determined with the given information

f) When the volume of the reaction is decreased at constant T the:

- a) equilibrium position will shift to the right
- b) equilibrium position will shift to the left
- c) value of K_p will increase
- d) value of K_p will decrease
- e) a and c

2. (18) For the following reaction and given starting conditions, calculate the reaction quotient (Q) and indicate whether the equilibrium position will shift to right, shift to the left, or stay the same.



a) $P_{\text{SO}_2} = 0.50 \text{ atm}$ $P_{\text{O}_2} = 0.50 \text{ atm}$ $P_{\text{SO}_3} = 0 \text{ atm}$

b) $P_{\text{SO}_2} = 1.0 \text{ atm}$ $P_{\text{O}_2} = 1.0 \text{ atm}$ $P_{\text{SO}_3} = 1.0 \text{ atm}$

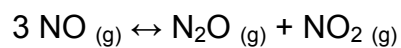
c) $P_{\text{SO}_2} = 2.0 \text{ atm}$ $P_{\text{O}_2} = 1.0 \text{ atm}$ $P_{\text{SO}_3} = 2.0 \text{ atm}$

d) $P_{\text{SO}_2} = 0.5 \text{ atm}$ $P_{\text{O}_2} = 0.25 \text{ atm}$ $P_{\text{SO}_3} = 1.0 \text{ atm}$

e) $P_{\text{SO}_2} = 1.000 \text{ atm}$ $P_{\text{O}_2} = 0.500 \text{ atm}$ $P_{\text{SO}_3} = 0.250 \text{ atm}$

f) What are the equilibrium partial pressures resulting from the starting conditions given in part e? **Use successive approximation for this, not a calculator!**

3. (6) As the temperature is increased from 25 °C to 125 °C, the value for the equilibrium constant of the reaction shown below decreases from 1.8×10^{18} to 2.0×10^{11} . Is this reaction endothermic or exothermic? Indicate where the energy term should appear.



4. (20) Calculate the pH of the following solutions. **NOTE FOR GETTING FULL CREDIT:** If you set up an equilibrium expression including an x, indicate whether you can ignore it or not (i.e. do not simply run this through your calculator!). If you need to solve a quadratic equation, show how you use successive approximations to solve it (or write out the quadratic formula)!

a) 0.10 M HCl

b) 0.10 M NaOH

c) 3.0×10^{-5} M HNO₃

d) 5.0×10^{-10} M HClO₄

e) 1.0×10^{-3} M HC₂H₃O₂

f) 5.0×10^{-8} M KOH

5. (12) Sketch the titration curve of 100 ml of 0.100 M Na_2CO_3 with 0.100 M HCl. Indicate the value of the pH after 0.00 ml, 50.00 ml, 100.00 ml, 150.00 ml, and 200.00 ml total volume of acid have been added. Show how you determine the pH values.

6. (10) Indicate whether solutions of the following salts are acidic, basic, or neutral. Explain your answers.

a) NaCl

b) NaF

c) NaNO₃

d) FeCl₃

e) NH₄F

7. (14) a) What is the solubility of AgOH in water? $K_{sp} = 2.0 \times 10^{-8}$

b) What is the pH of this solution?

c) If you add 0.1 mol of solid NaOH to one liter of 0.1 M AgOH solution (assume no volume change), what is the new solubility of AgOH?

d) If you bubble 0.1 mol of gaseous HCl into the 0.1 M AgOH solution (assume no volume change), what is the new solubility of AgOH?

8. (10) Rank the following in increasing order of base strength:

H_2O , F^- , Cl^- , NO_2^- and CN^-

9. (6) Which of the acids listed on the cover page would be most appropriate for use in preparing a buffer at pH 5.0? Explain.

10. (12) You are stuck on a desert island and need to make 1.00 L of 0.100 M phosphate buffer at pH 7.40 for an emergency blood transfusion. Luckily you are stranded with stock solutions of 1.0 M Na_3PO_4 , 1.0 M Na_2HPO_4 , and 1.0 M NaH_2PO_4 , as well as an empty 1.00 L graduated cylinder and an endless supply of pure water. Describe how you would make such a buffer.