

## CHEM 142 - Exam 2

## Version A

**!!! DO NOT OPEN THIS EXAM BOOK UNTIL  
TOLD TO DO SO BY THE INSTRUCTOR !!!**

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**Instructor:** Dr. Kari Pederson **NO GRAPHING CALCULATORS ALLOWED**

**Date:** Friday, August 5 **ONLY CALCULATORS MAY BE USED AS CALCULATORS**  
(you may not use your *cellular phone* as a calculator)

**Time:** 9:40-10:40am

**NO HEADPHONES ALLOWED (EARPLUGS ARE OK)**

**Location:** BAG 154

**NO HATS WITH BRIMS ALLOWED**

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**!!! PLEASE READ THIS !!!**

Indicate *all* of the following on your scantron form or **five points**  
will be deducted from your exam score:

**First Name, Last Name, Student Number, Section, Exam Version**

**YOUR FULL NAME:**

\_\_\_\_\_

*first name*

\_\_\_\_\_

*last name*

**YOUR SECTION/SEAT:**

\_\_\_\_\_

*discussion section*

\_\_\_\_\_

*seat number*

<b>Question</b>	<b>Points Possible</b>	<b>Score</b>
1-8	24	
9-16	40	
17-24	16	
25	20	
Scantron Info?	-5	

<b>TOTAL</b>	<b>100</b>	
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**MULTIPLE CHOICE: CONCEPTS. 8 @ 3 pts each → 24 POINTS TOTAL**

Please mark the *one* correct answer for each of the following questions on your scantron.

1. Which of the following statements is(are) false?  
Oxidation and reduction
- accompany all chemical changes.
  - result in a change in the oxidation states of the species involved.
  - describe the loss and gain of electron(s), respectively.
  - cannot occur independently of each other.
- A) I only  
B) II only  
C) III only  
D) IV only  
E) II, III, and IV
2. In which of the following compounds does nitrogen have the most positive oxidation state?
- A)  $\text{NH}_4\text{Cl}$       **N: -3**  
B)  $\text{HNO}_3$         **N: +5**  
C)  $\text{N}_2\text{O}$          **N: +1**  
D)  $\text{NaNO}_2$       **N: +3**  
E)  $\text{NO}_2$          **N: +4**
3. A rigid container contains 10.0 g of chlorine gas. With the temperature kept constant, 10.0 g of oxygen gas is added. What happens?
- A) The pressure in the container doubles.  
B) The pressure in the container increases by less than a factor of 2.  
C) **The pressure in the container increases by more than a factor of 2.**  
D) The pressure stays the same size, but the volume increases.  
E) The pressure decreases by a factor of 2.
- $P \propto n \rightarrow 10.0\text{g O}_2$  more moles than  $10.0\text{g Cl}_2$  means total number of moles will increase by more than a factor of two, therefore total pressure will increase by more than a factor of two.**
4. Under which of the following conditions does a gas behave most ideally?
- A) STP  
B)  $P = 0.50 \text{ atm}, T = 0.0^\circ\text{C}$   
C)  **$P = 0.50 \text{ atm}, T = 100.0^\circ\text{C}$**   
D)  $P = 1.0 \text{ atm}, T = 100.0^\circ\text{C}$   
E)  $P = 2.0 \text{ atm}, T = -100.0^\circ\text{C}$

5. Consider three 1 L flasks at the same temperature and pressure. Flask A contains CO gas, flask B contains N<sub>2</sub> gas, and flask C contains O<sub>2</sub> gas. In which flask do the molecules have the greatest kinetic energy?
- A) flask A  
B) flask B  
C) flask C  
D) The molecules in two of the flasks have the same kinetic energy.  
E) The molecules in all of the flasks have the same kinetic energy.
6. Four identical 1.0 L flasks contain the gases Ne, CH<sub>4</sub>, N<sub>2</sub>, and F<sub>2</sub>, each at 0°C and 1 atm pressure. For which gas do the molecules have the lowest root mean square velocity ( $u_{rms}$ )?
- A) Ne  
B) CH<sub>4</sub>  
C) N<sub>2</sub>  
D) F<sub>2</sub>  
E) The molecules of all the gases have the same root mean square velocity.

$$u_{rms} \propto \frac{1}{MM} \rightarrow \text{Highest MM corresponds to lowest } u_{rms}$$

7. Consider the reaction  $C(s) + H_2O(g) \rightleftharpoons CO(g) + H_2(g)$  at  $T = 900\text{ K}$ , where it is exothermic with equilibrium constant  $K = 0.64$ . With the system at equilibrium, more H<sub>2</sub>(g) is added. This will result in \_\_\_\_\_.
- A) an increase in  $K_p$ .  
B) a decrease in  $K_p$ .  
C) a shift in the equilibrium position to the right (products).  
D) a shift in the equilibrium position to the left (reactants).  
E) none of these
8. The  $K$  for the reaction,  $NH_4^+(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + NH_3(aq)$ , is called
- A)  $K_b$  for NH<sub>4</sub><sup>+</sup>  
B)  $K_b$  for NH<sub>3</sub>  
C)  $K_a$  for NH<sub>4</sub><sup>+</sup>  
D)  $K_a$  for NH<sub>3</sub>  
E) none of the above

**MULTIPLE CHOICE: SHORT CALCULATIONS.** 8 @ 5 pts each → **40 TOTAL POINTS**Please mark the *one* correct answer for each of the following questions on your scantron.

9. A student weighs out 0.568 g of KHP (molar mass = 204 g/mol) and titrates to the equivalence point with 36.78 mL of a stock NaOH solution. What is the concentration of the stock NaOH solution? KHP is an acid with one acidic proton.
- A) 0.100 M  
 B) 3.15 M  
 C) 0.115 M  
 D) 0.0757 M  
 E) none of these

$$0.568g \text{ KHP} \times \frac{1\text{mol KHP}}{204g \text{ KHP}} = 2.78 \times 10^{-3} \text{ mol KHP}$$

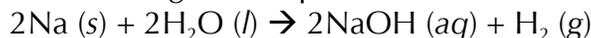
$$2.78 \times 10^{-3} \text{ mol KHP} \times \frac{1\text{mol NaOH}}{1\text{mol KHP}} = 2.78 \times 10^{-3} \text{ mol NaOH}$$

$$\frac{2.78 \times 10^{-3} \text{ mol NaOH}}{0.03678L} = 0.0757M \text{ NaOH}$$

10. A balloon is inflated with helium to a volume of 4.5 L at 37°C. If you take the balloon outside on a cold day and the volume decreases to 4.0 L, what is the temperature outside?
- A) 276 K  
 B) 306 K  
 C) 283 K  
 D) 349 K  
 E) none of the above

$$\frac{T_1}{V_1} = \frac{T_2}{V_2} \rightarrow T_2 = \frac{T_1}{V_1} \times V_2 = \frac{310K}{4.5L} \times 4.0L = 276K$$

11. A piece of sodium metal undergoes complete reaction with water as follows:



The hydrogen gas generated is collected over water at 25°C. The volume of gas is 216 mL measured at 1.00 atm. How many grams of sodium reacted? (The vapor pressure of water at 25°C is 0.0313 atm.)

- A) 0.393 g  
 B) 0.197 g  
 C) 0.203 g  
 D) 0.406 g  
 E) 3.96 g

$$P_{\text{H}_2} = P_{\text{total}} - P_{\text{H}_2\text{O}} = 1.00\text{ atm} - 0.0313\text{ atm} = 0.9687\text{ atm}$$

$$PV = nRT \rightarrow n = \frac{PV}{RT} = \frac{0.9687\text{ atm} \cdot 0.216\text{ L}}{0.08206 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}} \cdot 298\text{ K}} = 8.56 \times 10^{-3} \text{ mol H}_2$$

$$8.56 \times 10^{-3} \text{ mol H}_2 \times \frac{2 \text{ mol Na}}{1 \text{ mol H}_2} = 1.71 \times 10^{-2} \text{ mol Na}$$

$$1.71 \times 10^{-2} \text{ mol Na} \times \frac{22.98977 \text{ g Na}}{1 \text{ mol Na}} = 0.393 \text{ g Na}$$

12. The diffusion rate of H<sub>2</sub> gas is 4.47 times as great as that of a certain noble gas (both gases are at the same temperature). What is the noble gas?

- A) He  
 B) Ne  
 C) Ar  
 D) Kr  
 E) Xe

$$\frac{\text{rate}_1}{\text{rate}_2} = \frac{\sqrt{MM_2}}{\sqrt{MM_1}} \rightarrow MM_2 = \left( \frac{\text{rate}_1}{\text{rate}_2} \times \sqrt{MM_1} \right)^2 = (4.47 \times \sqrt{2})^2 = 39.9 \text{ g/mol} \rightarrow \text{Ar}$$

13. What is the molar mass of a gas that has a density of 5.75 g/L at STP?

- A) 3.90 g/mol  
 B) 129 g/mol  
 C) 176 g/mol  
 D) 1.91 × 10<sup>4</sup> g/mol  
 E) none of the above

$$PV = \frac{m}{MM} RT \rightarrow MM = \frac{m}{V} \times \frac{RT}{P} = (5.75 \text{ g/L}) \frac{\left( 0.08206 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}} \right) 273\text{ K}}{1\text{ atm}} = 129 \text{ g/mol}$$

14. The equilibrium constant for  $2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{SO}_3(\text{g})$  is 0.76 at 900 K. What is the equilibrium constant for the reaction  $\text{SO}_3(\text{g}) \rightleftharpoons \text{SO}_2(\text{g}) + \frac{1}{2}\text{O}_2(\text{g})$  at the same temperature?
- A) -0.76  
 B) 2.6  
 C) -0.38  
 D) 1.1  
 E) -0.87

$$K' = K^{-1/2} = (0.76)^{-1/2} = 1.1$$

15. For the reaction  $2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{SO}_3(\text{g})$ ,  $K_c = 0.25$  at  $25^\circ\text{C}$ . An equilibrium mixture is found to contain  $[\text{SO}_2] = [\text{SO}_3] = 0.20\text{ M}$ . What is the concentration of  $\text{O}_2(\text{g})$  in the flask?
- A) 4.00 M  
 B) 1.25 M  
 C) 2.00 M  
 D) 0.25 M  
 E) none of the above

$$K_c = \frac{[\text{SO}_3]^2}{[\text{SO}_2]^2 [\text{O}_2]} \rightarrow [\text{O}_2] = \frac{[\text{SO}_3]^2}{[\text{SO}_2]^2 K_c} = \frac{0.2^2}{0.2^2 \cdot 0.25} = 4.00\text{ M}$$

16. A sample of  $\text{HNO}_3$  is found to have a pH of 4.40. This solution is \_\_\_\_\_.
- A) acidic with  $[\text{HNO}_3] = 4.0 \times 10^{-5}\text{ M}$  and  $\text{pOH} = 9.60$   
 B) acidic with  $[\text{HNO}_3] = 2.5 \times 10^{-4}\text{ M}$  and  $\text{pOH} = 4.40$   
 C) basic with  $[\text{HNO}_3] = 4.0 \times 10^{-5}\text{ M}$  and  $\text{pOH} = 9.60$   
 D) basic with  $[\text{HNO}_3] = 2.5 \times 10^{-4}\text{ M}$  and  $\text{pOH} = 4.40$   
 E) acidic with  $[\text{HNO}_3] = 2.5 \times 10^{-4}\text{ M}$  and  $\text{pOH} = 9.60$

**pH < 7 → acidic**

$$\text{pOH} = 14.00 - 4.40 = 9.60$$

$$[\text{H}^+] = 10^{-4.40} = 4.0 \times 10^{-5}\text{ M H}^+$$

$$4.0 \times 10^{-5}\text{ M H}^+ \times \frac{1\text{ mol HNO}_3}{1\text{ mol H}^+} = 4.0 \times 10^{-5}\text{ M HNO}_3$$

**MATCHING.** 8 @ 2 pts each → **16 POINTS TOTAL**

Please indicate the letter of the *one* best answer for each of the following questions in the blank. Each answer is used no more than *once*.

17. Chemical equilibrium is microscopically \_\_\_\_\_ **A** \_\_\_\_\_.

18. The following reaction represents a \_\_\_\_\_ **C** \_\_\_\_\_ equilibria.  
 $\text{CaCO}_3 (s) \rightleftharpoons \text{CaO} (s) + \text{CO}_2 (g)$

19. The following is an example of a \_\_\_\_\_ **S** \_\_\_\_\_ reaction.  
 $\text{Pb}(\text{NO}_3)_2 (aq) + \text{Na}_2\text{SO}_4 (aq) \rightleftharpoons \text{PbSO}_4 (s) + 2 \text{NaNO}_3 (aq)$

20. Heating magnesium hydroxide produces magnesium oxide and water.  
 $\text{Mg}(\text{OH})_2 (s) \rightleftharpoons \text{MgO} (s) + \text{H}_2\text{O} (l)$   
 This would be classified as a \_\_\_\_\_ **K** \_\_\_\_\_ reaction.

21. For the following reaction,  $K_c$  is \_\_\_\_\_ **I** \_\_\_\_\_  $K_p$ .  
 $\text{N}_2 (g) + \text{O}_2 (g) \rightleftharpoons 2 \text{NO} (g)$

22. For a certain reaction at 25.0°C, the value of  $K$  is  $1.2 \times 10^{-3}$ . At 50.0°C the value of  $K$  is  $3.4 \times 10^{-1}$ . This means that the reaction is \_\_\_\_\_ **B** \_\_\_\_\_.

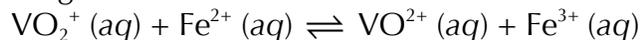
23.  $\text{HClO}_4$  is best classified as a \_\_\_\_\_ **M** \_\_\_\_\_.

24.  $\text{H}_2\text{PO}_4^-$  is the \_\_\_\_\_ **Q** \_\_\_\_\_ of  $\text{HPO}_4^{2-}$ .

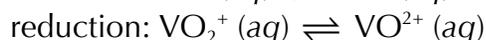
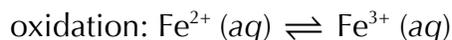
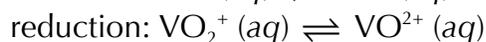
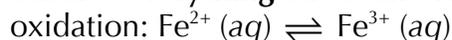
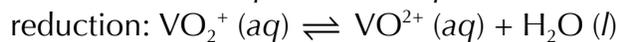
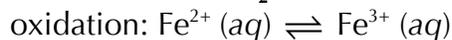
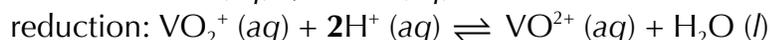
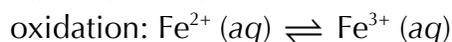
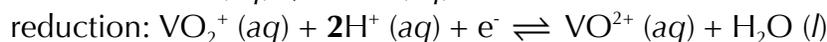
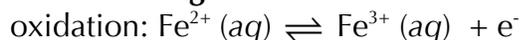
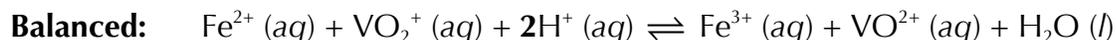
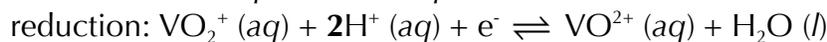
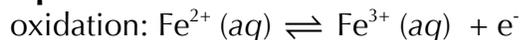
- |                       |                   |                       |                   |
|-----------------------|-------------------|-----------------------|-------------------|
| A) dynamic            | B) endothermic    | C) heterogeneous      | D) greater than   |
| E) static             | F) exothermic     | G) homogeneous        | H) less than      |
| I) equal to           | J) combination    | K) decomposition      | L) neutralization |
| M) strong acid        | N) weak acid      | O) strong base        | P) weak base      |
| Q) conjugate acid     | R) conjugate base | S) double replacement |                   |
| T) single replacement | U) combustion     |                       |                   |

**LONG ANSWER. 20 POINTS TOTAL**

25. The following reaction occurs in acidic solution:



A) What is the balanced equation for this reaction? (6 pts)

**balance everything but O and H****balance O with H<sub>2</sub>O****balance H with H<sup>+</sup>****balance charges with e<sup>-</sup>****Equalize electron transfer**

**Please use your answer from part A for the calculations in parts B-C. If you are unable to write a balanced equation, use the following balanced chemical reaction for the remainder of the problem:**



B) What is the equilibrium constant expression,  $K_c$ , for your balanced reaction? (2 pts)

$$K_c = \frac{[\text{Fe}^{3+}][\text{VO}^{2+}]}{[\text{Fe}^{2+}][\text{VO}_2^+][\text{H}^+]^2} \quad \text{OR} \quad K_c = \frac{[\text{Ag}^{2+}]^2[\text{Mn}^{2+}]}{[\text{Ag}^+]^2[\text{H}^+]^4}$$

C) A laboratory chemist mixes 1.0 mol of each aqueous and gaseous product or reactant in a rigid 2.0 L container. After the reaction reaches equilibrium, 1.25 mol of the  $Fe^{3+}$  (or  $Ag^{2+}$ ) is observed.

i) When the system has reached equilibrium, what are the concentrations of all aqueous and gaseous reactants and products? (10 pts)

	$[Fe^{2+}]$	$[VO_2^+]$	$[H^+]$	$[Fe^{3+}]$	$[VO^{2+}]$
Initial	0.5	0.5	0.5	0.5	0.5
Change	-x	-x	-2x	+x	+x
Equilibrium	0.5-x	0.5-x	0.5-2x	0.5+x	0.5+x

$$\text{At equilibrium, } [Fe^{3+}] = \frac{1.25 \text{ mol}}{2.0 \text{ L}} = 0.625 \text{ M} \quad 0.5 + x = 0.625 \rightarrow x = 0.125 \text{ M}$$

$$[Fe^{2+}] = 0.375 \text{ M}, [VO_2^+] = 0.375 \text{ M}, [H^+] = 0.25 \text{ M}, [Fe^{3+}] = 0.625 \text{ M}, \\ [VO^{2+}] = 0.625 \text{ M}$$

OR

	$[Ag^+]$	$[H^+]$	$[Mn^{2+}]$	$[Ag^{2+}]$
Initial	0.5	0.5	0.5	0.5
Change	-2x	-4x	+x	+2x
Equilibrium	0.5-2x	0.5-4x	0.5+x	0.5+2x

$$\text{At equilibrium, } [Ag^{2+}] = \frac{1.25 \text{ mol}}{2.0 \text{ L}} = 0.625 \text{ M} \quad 0.5 + 2x = 0.625 \rightarrow x = 0.0625 \text{ M}$$

$$[Ag^+] = 0.375 \text{ M}, [H^+] = 0.25 \text{ M}, [Mn^{2+}] = 0.5625 \text{ M}, [Ag^{2+}] = 0.625 \text{ M}$$

ii) What is the value of  $K_c$ ? (2 pts)

$$K_c = \frac{[Fe^{3+}]^2 [VO^{2+}]}{[Fe^{2+}]^2 [VO_2^+] [H^+]^2} = \frac{(0.625 \text{ M})(0.625 \text{ M})}{(0.375 \text{ M})(0.375 \text{ M})(0.25 \text{ M})^2} = 44.4 \text{ M}^{-2}$$

OR

$$K_c = \frac{[Ag^{2+}]^2 [Mn^{2+}]}{[Ag^+]^2 [H^+]^4} = \frac{(0.625 \text{ M})^2 (0.5625 \text{ M})}{(0.375 \text{ M})^2 (0.25 \text{ M})^4} = 400$$