

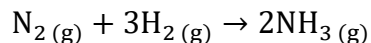
## Spring 2023 CHM2046 Exam 2 Review

**\*The material covered in this review is from Chapters 16-21, and 23\***

**\*\*\*Different professors cover different material\*\*\***

### Chapter 16: Kinetics

1. Ammonia is generated on an industrial scale using the Haber-Bosch process. The reaction is shown below:



Find the rate law, individual, and overall reaction orders and the average value of k for the reaction.

Experiment	Initial rate (mol/L*s)	Initial [N <sub>2</sub> ] (mol/L)	Initial [H <sub>2</sub> ] (mol/L)
1	$1.9 \times 10^{-12}$	0.0113	0.0011
2	$1.7 \times 10^{-11}$	0.0220	0.0033
3	$9.3 \times 10^{-12}$	0.0550	0.0011
4	$4.9 \times 10^{-11}$	0.0220	0.0056

Rate Law:  $\text{Rate} = k[\text{N}_2]^m[\text{H}_2]^n$

N<sub>2</sub> Order: 1<sup>st</sup> order

H<sub>2</sub> Order: 2<sup>nd</sup> order

Overall Reaction Order: 3<sup>rd</sup> order

Average Value of k:  $1.39 \times 10^{-6} \text{ L/mol*s}$

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2.  $\text{H}_2\text{O}_2$  decomposes into  $\text{H}_2$  and  $\text{O}_2$  in a first order reaction. If the initial concentration is 4.38 M, the final concentration is 2.91 M, and the decomposition takes place over 10 minutes, what is  $k$ ? Using the calculated  $k$ , how long will it take to decompose 25% of the initial amount?

- $k=0.035/\text{min}$ ; 7 minutes
- $k=0.041/\text{min}$ ; 7 minutes
- $k=0.035/\text{min}$ ; 10 minutes
- $k=0.041/\text{min}$ ; 10 minutes
- $k=0.059/\text{min}$ ; 7 minutes
- $k=0.059/\text{min}$ ; 10 minutes

3. Which of the following statements are true regarding exothermic reactions?

I. Heat is absorbed

II. Heat is released

III. Heat is a reactant

IV. Heat is a product

V. Heat and enthalpy will be on the same side of the equation

VI. Heat and enthalpy will be on opposite sides of the equation

VII. The energy of the reactants is higher than the products

VIII. The energy of the reactants is lower than the products

- I, III, V, VII
- II, IV, V, VII
- I, II, III, IV
- V, VI, VII, VIII
- I, IV, V, VIII
- II, III, V, VII

4. Which of the following statements are true regarding endothermic reactions?

I. Heat is absorbed

II. Heat is released

III. Heat is a reactant

IV. Heat is a product

V. Heat and enthalpy will be on the same side of the equation

VI. Heat and enthalpy will be on opposite sides of the equation

VII. The energy of the reactants is higher than the products

VIII. The energy of the reactants is lower than the products

- I, III, V, VIII
- II, IV, VI, VII
- I, II, III, IV
- V, VI, VII, VIII
- I, IV, V, VIII
- II, III, V, VII

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5. Which of the following statements are true regarding catalysts?

I. Catalysts cause products to form slower

IV. Catalysts are not reformed

VII. Catalysts affect reaction rate; it increases

II. Catalysts cause products to form faster

V. Catalysts lower activation energy

VIII. Catalysts affect reaction rate; it decreases

III. Catalysts increase activation energy

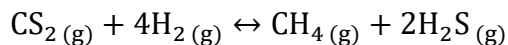
VI. Catalysts are reformed

IX. Catalysts don't affect reaction rate

- a. I, III, VI, IX
- b. II, III, VI, IX
- c. II, V, VI, VII
- d. I, IV, VI, VIII
- e. II, IV, VI, VII

### Chapter 17: Equilibrium

1. Given the following chemical reaction, calculate the  $K_p$  given that the  $K_c$  is 0.28 at  $900^\circ\text{C}$ .



- a.  $7.5 \times 10^{-5}$
- b.  $8.1 \times 10^{-2}$
- c.  $3.6 \times 10^{-3}$
- d.  $3.0 \times 10^{-5}$
- e.  $2.9 \times 10^{-4}$

2. Which of the following statements regarding  $Q$  and  $K$  are true?

I. If  $K > Q$ , then the reaction proceeds to the right

IV. If the reaction proceeds to the left, it will create more products

VI. If  $K < Q$ , then the reaction proceeds to the left

II. If  $K = Q$ , then the reaction is at equilibrium

V. If  $K > Q$ , then the reaction proceeds to the left

VII. If  $K = Q$ , then the reaction proceeds to the right

III. If the reaction proceeds to the right, it will create more products

VIII. If  $K < Q$ , then the reaction is at equilibrium

- a. II, III, V, VIII
- b. I, II, III, VI
- c. IV, V, VI, VII
- d. VI, VII, VIII
- e. I, III, VI, VIII

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3. Fill in the table summarizing the effects of Le Chatelier's Principle.

Change	Effect on Equilibrium (Left or Right)	Effect on the value of K (Equilibrium Constant)
Increase [reactant]	Right (products)	None
Increase [product]	Left (reactants)	None
Decrease [reactant]	Left (reactants)	None
Decrease [product]	Right (products)	None
Increase pressure	Towards side with fewer moles of gas	None
Increase volume	Towards side with more moles of gas	None
Decrease pressure	Toward side with more moles of gas	None
Decrease volume	Towards side with fewer moles of gas	None
Increase pressure (inert gas)	No change in volume, no change; concentrations unchanged	None
Increase temperature	Towards absorption of heat (Endothermic shift right) (Exothermic shift left)	Endothermic, increases Exothermic, decreases
Decrease temperature	Towards release of heat (Endothermic shift left) (Exothermic shift right)	Endothermic, decreases Exothermic, increases
Add catalyst	None; forward and reverse rates increase equally	None

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### Chapter 18: Acid-Base Equilibria

1. Which of the following statements regarding acids, bases, and  $K_a$ s is true?

- |                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>I. The stronger the acid, the larger the <math>K_a</math>, the larger the <math>pK_a</math></p> <p>II. The stronger the acid, the larger the <math>K_a</math>, the smaller the <math>pK_a</math></p> <p>III. The weaker the acid, the lower the concentration of <math>H_3O^+</math>, the larger the <math>pK_a</math></p> <p>IV. The larger the <math>pK_a</math>, the smaller the <math>K_a</math></p> <p>V. A strong acid is a weak base</p> | <p>VI. <math>K_w</math>, <math>K_a</math>, and <math>K_b</math> are related to each other in the equation <math>K_w = K_a * K_b</math></p> <p>VII. The equilibrium of an acid base reaction goes from the stronger acid to the weaker acid</p> <p>VIII. The equilibrium of an acid base reaction goes from the weaker acid to the stronger acid</p> <p>IX. If the reaction proceeds to the right, <math>K_c &gt; 1</math>.</p> |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
- a. I, VIII  
 b. All but I, VIII  
 c. II, III, VII, VIII  
 d. IV, V, VII, VIII  
 e. I, III, IV, VII

2. Which of the following statements regarding pH is true?

- |                                                                                                                                                                                                                                                                |                                                                                                                                                                                   |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>I. Acidic solutions have a higher concentration of <math>OH^-</math></p> <p>II. Basic solutions have a higher concentration of <math>OH^-</math></p> <p>III. A neutral solution has an equal concentration of <math>H_3O^+</math> and <math>OH^-</math></p> | <p>IV. <math>K_w = \frac{[H_3O^+]}{[OH^-]}</math></p> <p>V. <math>K_w = [H_3O^+] * [OH^-]</math></p> <p>VI. <math>pH + pOH = 14</math></p> <p>VII. <math>pH - pOH = 14</math></p> |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
- a. I, II, IV, VII  
 b. II, III, V, VI  
 c. III, IV, V, VII  
 d. II, IV, VI

3. If an unknown weak acid is 0.798% dissociated in a 2.15M solution. What is the  $K_a$  of the acid, the  $pK_a$ , and the identity of the acid?

- a.  $2.46 * 10^{-3}$ , 10.5, Formic acid  
 b.  $5.12 * 10^{-5}$ , 3.14, Lactic acid  
 c.  $1.38 * 10^{-4}$ , 3.86, Lactic acid  
 d.  $9.17 * 10^{-4}$ , 4.68, Formic acid

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4. What are the equilibrium values of carbonic acid and the pH of a 1.34M solution?

$$[\text{H}_2\text{CO}_3] = 1.34\text{M}$$

$$[\text{HCO}_3^-] = 0.00077\text{M}$$

$$[\text{CO}_3^{2-}] = 4.7 \times 10^{-11}\text{M}$$

$$\text{pH} = 3.11$$

5. Which salts yield neutral solutions?

- a.  $\text{NH}_4\text{Cl}$
- b.  $\text{CaCl}_2$
- c.  $\text{LiNO}_3$
- d.  $\text{Fe}(\text{NO}_3)_3$
- e. B and C
- f. A and D
- g. None of the above

6. Which of the following act as Lewis acids?

- a.  $\text{Ba}^{2+}$
- b.  $\text{NH}_3$
- c.  $\text{AlCl}_3$
- d.  $\text{H}_2\text{O}$
- e. A and C
- f. B and D

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### Chapter 19: Ionic Equilibria in Aqueous Systems

1. What is the pH of a buffer of 0.83M  $(\text{CH}_3)_2\text{NH}_2\text{Cl}$  and 1.2M  $(\text{CH}_3)_2\text{NH}$  before and after adding 125mL of 0.75M HCl to 1 L of the buffer. (Info:  $\text{pK}_b$  of  $(\text{CH}_3)_2\text{NH}=3.23$ ).

- a. 9.776 -> 10.93
- b. 2.726 -> 7.901
- c. 10.93 -> 10.85
- d. 7.901 -> 2.726

2. Given a pH of 10.73, what is the ratio of a buffer of  $[\text{NH}_3]/[\text{NH}_4^+]$ , and using that what mass of  $\text{NH}_4\text{Cl}$  would need to be added to 2438 mL of 0.56M  $\text{NH}_3$  to make the buffer? ( $\text{K}_b$  of  $\text{NH}_3=1.76 \times 10^{-5}$ )

- a. 1.48; 97.2 g
- b. 1.48; 49.3 g
- c. 7.51; 97.2 g
- d. 7.51; 49.3 g
- e. 8.61; 52.3 g

3. Magnesium phosphate is an anticaking agent for silicone-containing cleaning agents and salt. Its  $\text{K}_{\text{sp}}$  is  $1.04 \times 10^{-24}$ . If  $[\text{Mg}^{2+}]=[\text{PO}_4^{3-}]=3.6 \times 10^{-10}$  M, will magnesium phosphate precipitate?

- a. Yes,  $Q_{\text{sp}} > K_{\text{sp}}$
- b. No,  $Q_{\text{sp}} > K_{\text{sp}}$
- c. No,  $Q_{\text{sp}} = K_{\text{sp}}$
- d. Yes,  $Q_{\text{sp}} < K_{\text{sp}}$
- e. No,  $Q_{\text{sp}} < K_{\text{sp}}$

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4. Does the addition of  $\text{HNO}_3$  affect the solubility of calcium fluoride?

- a. Increases solubility
- b. Decreases solubility
- c. No effect on solubility

5. What is the pH at the equivalence point of 912 mL of 10.67 M  $\text{HBrO}$  with 15.02 M  $\text{NaOH}$ ?

- a. 12.84
- b. 13.74
- c. 2.29
- d. 11.71
- e. 6.91

### Chapter 20: Thermodynamics

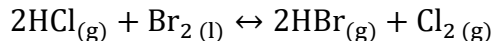
1. Fill in the following table on the spontaneity of  $\Delta G$ ,  $\Delta H$ ,  $\Delta S$

$\Delta G = \Delta H - T\Delta S$					
$\Delta G$	$\Delta H$	$-T\Delta S$	$\Delta S$	Spontaneity	Exothermic or Endothermic
-	-	-	+	Spontaneous at all temperatures (T)	Exothermic
+	+	+	-	Nonspontaneous at all T	Endothermic
+ or -	+	-	+	Spontaneous at high T ( $\Delta G < 0$ ), Nonspontaneous at low T ( $\Delta G > 0$ )	Endothermic
+ or -	-	+	-	Spontaneous at low T ( $\Delta G < 0$ ), Nonspontaneous at high T ( $\Delta G > 0$ )	Exothermic



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2. Find K at 298 K of the following reaction:

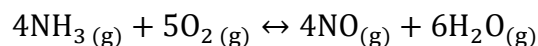


- a.  $8.41 \times 10^{-51}$
- b.  $5.89 \times 10^{-28}$
- c.  $1.64 \times 10^{-11}$
- d.  $9.37 \times 10^{-15}$

3. FeO(s) oxidizes into Fe<sub>2</sub>O<sub>3</sub>(s). If there is 1 mole of Fe<sub>2</sub>O<sub>3</sub>, does this reaction occur spontaneously at 298K? Given the values of  $\Delta H_{\text{rxn}}$ ,  $\Delta S_{\text{rxn}}$ , and  $\Delta S_{\text{univ}}$ .

- a. It is spontaneous;  $\Delta H_{\text{rxn}} = -560.7 \text{ kJ}$ ,  $\Delta S_{\text{rxn}} = -273.44 \text{ J/K}$  and  $\Delta S_{\text{univ}} = +1608 \text{ J/K}$
- b. It is not spontaneous;  $\Delta H_{\text{rxn}} = -560.7 \text{ kJ}$ ,  $\Delta S_{\text{rxn}} = -68.44 \text{ J/K}$  and  $\Delta S_{\text{univ}} = +1813 \text{ J/K}$
- c. It is spontaneous;  $\Delta H_{\text{rxn}} = +560.7 \text{ kJ}$ ,  $\Delta S_{\text{rxn}} = +68.44 \text{ J/K}$  and  $\Delta S_{\text{univ}} = -1813 \text{ J/K}$
- d. It is not spontaneous;  $\Delta H_{\text{rxn}} = +560.7 \text{ kJ}$ ,  $\Delta S_{\text{rxn}} = +68.44 \text{ J/K}$  and  $\Delta S_{\text{univ}} = -1813 \text{ J/K}$

4. Calculate the  $\Delta G^{\circ}_{\text{rxn}}$  at 25°C of the following reaction:



- a. +961 kJ
- b. +852 kJ
- c. -961 kJ
- d. -852 kJ
- e. +134 kJ
- f. -134 kJ

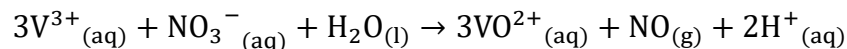
5. Calculate the standard entropy of the combustion of butane.

- a. -876 J/K
- b. +876 J/K
- c. -876 kJ
- d. +876 kJ

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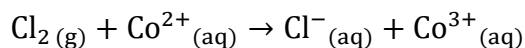
Chapter 21: Electrochemistry

1. Given the following reaction, what is the  $E^\circ$  value for vanadium, given that  $E^\circ_{\text{cell}}$  is 0.62 V and  $E^\circ$  of nitrate is 0.96 V?



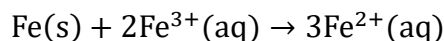
- a. -0.34V
- b. +0.67V
- c. -0.97V
- d. +0.34V
- e. +0.97V

2. Is the following reaction spontaneous? (Hint: Use the  $E^\circ_{\text{cell}}$  value)



- a. It is spontaneous;  $E^\circ_{\text{cell}} = +0.46\text{V}$
- b. It is spontaneous;  $E^\circ_{\text{cell}} = +0.92\text{V}$
- c. It is not spontaneous;  $E^\circ_{\text{cell}} = -0.46\text{V}$
- d. It is not spontaneous;  $E^\circ_{\text{cell}} = -0.92\text{V}$

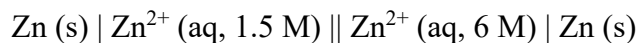
3. Is the following reaction spontaneous? If it is, what would the nonspontaneous form look like and calculate  $E^\circ_{\text{cell}}$  of the nonspontaneous reaction.



- a.  $\text{Fe}(\text{s}) + 2\text{Fe}^{3+}(\text{aq}) \rightarrow 3\text{Fe}^{2+}(\text{aq}); E^\circ_{\text{cell}} = +1.21\text{V}$
- b.  $3\text{Fe}^{2+}(\text{aq}) \rightarrow \text{Fe}(\text{s}) + 2\text{Fe}^{3+}(\text{aq}); E^\circ_{\text{cell}} = +1.21\text{V}$
- c.  $\text{Fe}(\text{s}) + 2\text{Fe}^{3+}(\text{aq}) \rightarrow 3\text{Fe}^{2+}(\text{aq}); E^\circ_{\text{cell}} = -1.21\text{V}$
- d.  $3\text{Fe}^{2+}(\text{aq}) \rightarrow \text{Fe}(\text{s}) + 2\text{Fe}^{3+}(\text{aq}); E^\circ_{\text{cell}} = -1.21\text{V}$

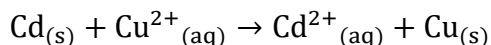
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4. What is the cell potential for the following concentration cell? (Hint: Use the Nernst Equation)



- a. +0.021V
- b. +0.018V
- c. -0.021V
- d. +0.97V
- e. -1.64V

5. Given the following reaction, the  $\Delta G^\circ = -143 \text{ kJ/mol}$  of reaction. What is the  $K$  at  $25^\circ\text{C}$ , and  $E^\circ_{\text{cell}}$ ?



- a.  $K=1.17 \times 10^{25}$ ;  $E^\circ_{\text{cell}}=0.74\text{V}$
- b.  $K=1.25 \times 10^{-25}$ ;  $E^\circ_{\text{cell}}=-0.58\text{V}$
- c.  $K=5.51 \times 10^{15}$ ;  $E^\circ_{\text{cell}}=0.76\text{V}$
- d.  $K=8.25 \times 10^{25}$ ;  $E^\circ_{\text{cell}}=0.98\text{V}$
- e.  $K=1.81 \times 10^{25}$ ;  $E^\circ_{\text{cell}}=-1.67\text{V}$

6. Fill the following table on the comparison of voltaic and electrolytic cells

Cell Type	$\Delta G$	$E_{\text{cell}}$	Spontaneity	Electrode		
				Name	Process	Sign
Voltaic	<0	>0	Spontaneous	Anode	Oxidation	-
				Cathode	Reduction	+
Electrolytic	>0	<0	Nonspontaneous	Anode	Oxidation	+
				Cathode	Reduction	-

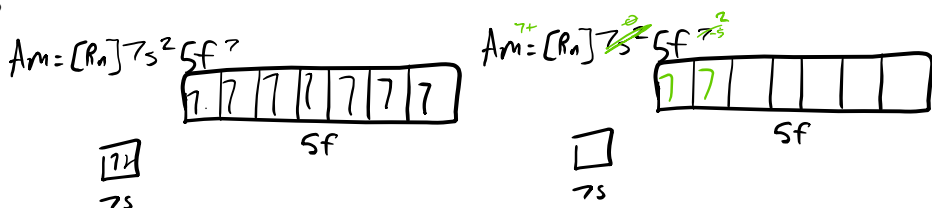
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Chapter 23: Transition Elements (This has only been covered by one professor)1. How many unpaired electrons are  $\text{Sm}^{2+}$ ,  $\text{Sm}^{3+}$ ,  $\text{Dy}^{3+}$ , and  $\text{Dy}^{4+}$ ?

- a. 6, 5, 5, 6       $\text{Sm}^{2+}$  6 unpaired  
 b. 6, 6, 6, 6       $\text{Sm}^{3+}$  5 unpaired  
 c. 5, 5, 5, 5       $\text{Dy}^{3+}$  5 unpaired  
 d. 5, 6, 6, 5       $\text{Dy}^{4+}$  6 unpaired  
 e. 5, 7, 4, 6  
 f. 7, 4, 4, 5

2.  $\text{AmO}_5^{3-}$  has a green color when in an aqueous solution. What is the oxidation state of Am in this molecule, how many unpaired electrons does it have, and what does its electron configuration look like?

- a. 3+, 5 unpaired  
 b. 2+, 7 unpaired  
 c. 6+, 3 unpaired  
 d. 7+, 2 unpaired  
 e. 5+, 5 unpaired



3. If an absorbed color has a wavelength of 600 nm, what is the observed color?

- a. Blue  
 b. Green  
 c. Orange  
 d. Violet  
 e. Red  
 f. Yellow

4. What is the coordination number and charge of the central metal ion in  $[\text{Co}(\text{en})_2\text{Br}_2]\text{NO}_3$ ?

- a. 4, 2+  
 b. 4, 4+  
 c. 6, 3+  
 d. 5, 5+  
 e. 6, 6+

5. How many unpaired electrons would you expect for  $[\text{CoF}_6]^{3-}$ , and give its energy diagram. Is it high spin or low spin?

- a. 6, low spin  
 b. 4, high spin  
 c. 6, high spin  
 d. 3, low spin

