

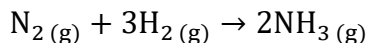
Spring 2023 CHM2046 Exam 2 Review

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

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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 ₂] (mol/L)	Initial [H ₂] (mol/L)
1	1.9×10^{-12}	0.0113	0.0011
2	1.7×10^{-11}	0.0220	0.0033
3	9.3×10^{-12}	0.0550	0.0011
4	4.9×10^{-11}	0.0220	0.0056

Rate Law:

N₂ Order:

H₂ Order

Overall Reaction Order:

Average Value of k

2. H₂O₂ decomposes into H₂ and O₂ 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?

- a. k=0.035/min; 7 minutes
- b. k=0.041/min; 7 minutes
- c. k=0.035/min; 10 minutes
- d. k=0.041/min; 10 minutes
- e. k=0.059/min; 7 minutes
- f. k=0.059/min; 10 minutes

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

- | | | |
|-------------------------|---|--|
| I. Heat is absorbed | V. Heat and enthalpy will be on the same side of the equation | VII. The energy of the reactants is higher than the products |
| II. Heat is released | | |
| III. Heat is a reactant | VI. Heat and enthalpy will be on opposite sides of the equation | VIII. The energy of the reactants is lower than the products |
| IV. Heat is a product | | |
- a. I, III, V, VII
b. II, IV, V, VII
c. I, II, III, IV
d. V, VI, VII, VIII
e. I, IV, V, VIII
f. II, III, V, VII

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

- | | | |
|-------------------------|---|---|
| I. Heat is absorbed | V. Heat and enthalpy will be on the same side of the equation | VII. The energy of the reactants is higher than the products |
| II. Heat is released | | |
| III. Heat is a reactant | VI. Heat and enthalpy will be on opposite sides of the equation | VIII. The energy of the reactants will be lower than the products |
| IV. Heat is a product | | |
- a. I, III, V, VIII
b. II, IV, VI, VII
c. I, II, III, IV
d. V, VI, VII, VIII
e. I, IV, V, VIII
f. II, III, V, VII

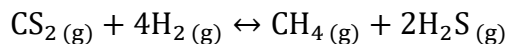
5. Which of the following statements are true regarding catalysts?

- | | | |
|---|--------------------------------------|--|
| 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

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Chapter 17: Equilibrium

1. Given the following chemical reaction, calculate the K_c given that the K_p is 0.28 at 900°C.



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

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

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

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

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

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

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

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

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

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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17.3 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]		
Increase [product]		
Decrease [reactant]		
Decrease [product]		
Increase pressure		
Increase volume		
Decrease pressure		
Decrease volume		
Increase pressure (inert gas)		
Increase temperature		
Decrease temperature		
Add catalyst		

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Chapter 18: Acid-Base Equilibria

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

- | | |
|---|---|
| I. The stronger the acid, the larger the K_a , the larger the pK_a | VI. K_w , K_a , and K_b are related to each other in the equation $K_w = K_a * K_b$ |
| II. The stronger the acid, the larger the K_a , the smaller the pK_a | VII. The equilibrium of an acid base reaction goes from the stronger acid to the weaker acid |
| III. The weaker the acid, the lower the concentration of H_3O^+ , the larger the pK_a | VIII. The equilibrium of an acid base reaction goes from the weaker acid to the stronger acid |
| IV. The larger the pK_a , the smaller the K_a | IX. If the reaction proceeds to the right, $K_c > 1$. |
| V. A strong acid is a weak base | |
- 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?

- | | |
|---|-------------------------------------|
| I. Acidic solutions have a higher concentration of OH^- | IV. $K_w = \frac{[H_3O^+]}{[OH^-]}$ |
| II. Basic solutions have a higher concentration of OH^- | V. $K_w = [H_3O^+] * [OH^-]$ |
| III. A neutral solution has an equal concentration of H_3O^+ and OH^- | VI. $pH + pOH = 14$ |
| | VII. $pH - pOH = 14$ |
- 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?

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

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

$[\text{CO}_3^{2-}] =$

pH =

5. Which salts yield neutral solutions?

- NH_4Cl
- CaCl_2
- LiNO_3
- $\text{Fe}(\text{NO}_3)_3$
- B and C
- A and D
- None of the above

6. Which of the following act as Lewis acids?

- Ba^{2+}
- NH_3
- AlCl_3
- H_2O
- A and C
- B and D

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: pK_b of $(\text{CH}_3)_2\text{NH}=3.23$).

- 8.776 -> 10.93
- 2.726 -> 7.901
- 10.93 -> 10.85
- 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 NH_4Cl would need to be added to 2438 mL of 0.56M NH_3 to make the buffer? (K_b of $\text{NH}_3=1.76 \times 10^{-5}$)

- 1.48; 97.2 g
- 1.48; 49.3 g
- 7.51; 97.2 g
- 7.51; 49.3 g
- 8.61; 52.3 g

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3. Magnesium phosphate is an anticaking agent for silicone-containing cleaning agents and salt. Its K_{sp} is 1.04×10^{-24} . If $[Mg^{2+}] = [PO_4^{3-}] = 3.6 \times 10^{-10}$ M, will magnesium phosphate precipitate?

- Yes, $Q_{sp} > K_{sp}$
- No, $Q_{sp} > K_{sp}$
- No, $Q_{sp} = K_{sp}$
- Yes, $Q_{sp} < K_{sp}$
- No, $Q_{sp} < K_{sp}$

4. Does the addition of HNO_3 affect the solubility of calcium fluoride?

- Increases solubility
- Decreases solubility
- No effect on solubility

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

- 12.84
- 13.74
- 2.29
- 11.71
- 6.91

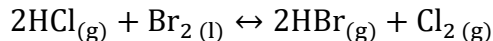
Chapter 20: Thermodynamics

1. Fill in the following table on the spontaneity of ΔG , ΔH , ΔS

$\Delta G = \Delta H - T\Delta S$					
ΔG	ΔH	$-T\Delta S$	ΔS	Spontaneity	Exothermic or Endothermic

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

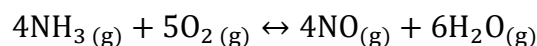


- a. 8.41×10^{-51}
- b. 5.89×10^{-28}
- c. 1.64×10^{-11}
- d. 9.37×10^{-15}

3. FeO(s) oxidizes into Fe₂O₃ (s). If there is 1 mole of Fe₂O₃, does this reaction occur spontaneously at 298K? Given the values of ΔH_{rxn} , ΔS_{rxn} , and ΔS_{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:



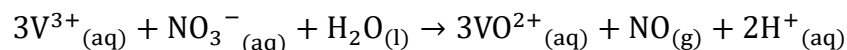
- a. +961 kJ
- b. +852 kJ
- c. -961 kJ
- d. -852 kJ
- e. +134 kJ
- f. -134 kJ

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

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

Chapter 21: Electrochemistry

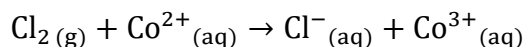
1. Given the following reaction, what is the E° value for vanadium, given that E°_{cell} is 0.62 V and E° of nitrate is 0.96 V?



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

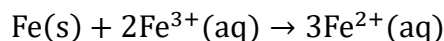
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2. Is the following reaction spontaneous? (Hint: Use the E°_{cell} value)



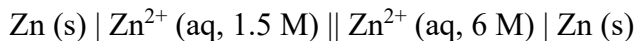
- It is spontaneous; $E^\circ_{\text{cell}} = +0.46\text{V}$
- It is spontaneous; $E^\circ_{\text{cell}} = +0.92\text{V}$
- It is not spontaneous; $E^\circ_{\text{cell}} = -0.46\text{V}$
- It is not spontaneous; $E^\circ_{\text{cell}} = -0.92\text{V}$

3. Is the following reaction spontaneous? If it is, what would the nonspontaneous form look like and calculate E°_{cell} of the nonspontaneous reaction.



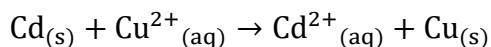
- $\text{Fe}(\text{s}) + 2\text{Fe}^{3+}(\text{aq}) \rightarrow 3\text{Fe}^{2+}(\text{aq}); E^\circ_{\text{cell}} = +1.21\text{V}$
- $3\text{Fe}^{2+}(\text{aq}) \rightarrow \text{Fe}(\text{s}) + 2\text{Fe}^{3+}(\text{aq}); E^\circ_{\text{cell}} = +1.21\text{V}$
- $\text{Fe}(\text{s}) + 2\text{Fe}^{3+}(\text{aq})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

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



- +0.021V
- +0.018V
- 0.021V
- +0.97V
- 1.64V

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



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

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

Cell Type	ΔG	E_{cell}	Spontaneity	Electrode		
				Name	Process	Sign
Voltaic				Anode		
				Cathode		
Electrolytic				Anode		
				Cathode		

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Chapter 23: Transition Elements (This has only been covered by one professor)

- How many unpaired electrons are Sm^{2+} , Sm^{3+} , Dy^{3+} , and Dy^{4+} ?
 - 6, 5, 5, 6
 - 6, 6, 6, 6
 - 5, 5, 5, 5
 - 5, 6, 6, 5
 - 5, 7, 4, 6
 - 7, 4, 4, 5
- 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?
 - 3+, 5 unpaired
 - 2+, 7 unpaired
 - 6+, 3 unpaired
 - 7+, 2 unpaired
 - 5+, 5 unpaired
- If an absorbed color has a wavelength of 600 nm, what is the observed color?
 - Blue
 - Green
 - Orange
 - Violet
 - Red
 - Yellow
- What is the coordination number and charge of the central metal ion in $[\text{Co}(\text{en})_2\text{Br}_2]\text{NO}_3$?
 - 4, 2+
 - 4, 4+
 - 6, 3+
 - 5, 5+
 - 6, 6+
- How many unpaired electrons would you expect for $[\text{CoF}_6]^{3-}$, and give its energy diagram. Is it high spin or low spin?
 - 6, low spin
 - 4, high spin
 - 6, high spin
 - 3, low spin