



**Chem 1105-Summer Final Exam**

**Date: August 12, 2015**

**Instructor: Calvin Howley**

**Time Period: 3 hours**

**Student:** \_\_\_\_\_

**Student #:** \_\_\_\_\_

**Instructions:**

Please turn off all cell phones. Only scientific calculators are allowed in the exam room. Students found to be using any electronic organizer or other electronic device during the exam will be given a grade of zero and asked to leave the testing area.

All answers are to be done on test paper. If more room is needed use the back side of the paper and indicate.

Read all questions carefully.

Answer all questions for full point value. Partial marks may be awarded for incomplete questions.

Make sure you have all data sheets and test pages.

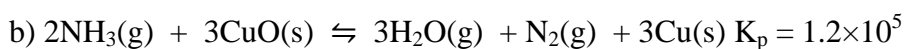
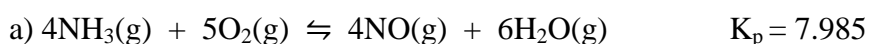
Complete as many questions as soon as possible and then go back to incomplete questions.

Test papers not turned in to the instructor at the end of the test period will not be accepted.

**Part I: Short Answer****Instructions: Circle the correct answer(s) or fill your answer in the space provided.**1. Coal, which is primarily carbon, can be converted to natural gas, primarily CH<sub>4</sub>:Circle the **change(s)** below that will favour the formation of CH<sub>4</sub> at equilibrium.

- a) adding more C(s) to the equilibrium.      b) adding more H<sub>2</sub> to the equilibrium.  
 c) raising the temperature.      d) lowering the temperature of the reaction mixture.  
 e) decreasing the volume of the system.      f) lowering the pressure of the system.

2. Determine the position of the equilibrium and state in the boxes below if the equilibrium favours the formation of “products” or “reactants” or lies “in the middle” for the following chemical equations:

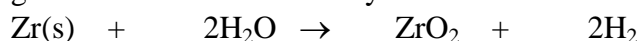
3. An aqueous solution is 0.10 M in the weak base methylamine, CH<sub>3</sub>NH<sub>2</sub>. Which **one** of the following is true for this solution?

- a)  $[\text{H}^+\text{(aq)}] = 0.10 \text{ M}$       b)  $[\text{OH}^-\text{(aq)}] = 0.10 \text{ M}$       c)  $\text{pH} < 7$       d)  $\text{pH} > 7$

4. A solution has a pH of 5.00. In this solution,  $[\text{OH}^-\text{(aq)}]$ , must be

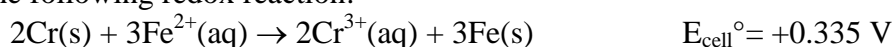
- a)  $1.0 \times 10^{-9} \text{ M}$       b)  $1.0 \times 10^{-7} \text{ M}$       c) greater than  $1.0 \times 10^{-5} \text{ M}$       d)  $1.0 \times 10^{-5} \text{ M}$

5. Consider the following redox reaction and identify:



- a) The species oxidized is \_\_\_\_\_.  
 b) The species reduced is \_\_\_\_\_.  
 c) The oxidizing agent is \_\_\_\_\_.  
 d) The reducing agent is \_\_\_\_\_.

6. Consider the following redox reaction:

Circle the **statement(s)** below that are **true**.

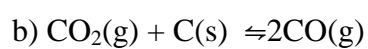
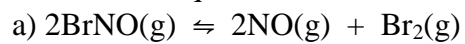
- a) The nonspontaneous reaction can be made to occur in an electrolysis cell.  
 b) The spontaneous reaction can be used to produce electricity in a voltaic cell.  
 c) The reaction occurs whenever Cr(s) and Fe<sup>2+</sup> are mixed in an aqueous solution.  
 d) Fe<sup>2+</sup> is reduced to Fe(s) at the cathode.  
 e) Fe<sup>2+</sup> is reduced to Fe(s) at the anode.

**Part II: Long Answer**

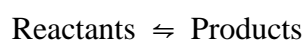
**Instructions: Fill your answer in the space provided. Show all work for full point value.**

**A. Equilibrium**

1. Write the equilibrium constant expressions( $K_c$ ) for the following:

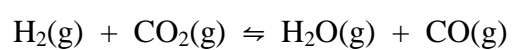


2. Explain why a system at equilibrium



is referred to as a “dynamic process” when the concentration of Reactants and Products is constant.

3. An industrial chemist puts 1.00 mole each of  $\text{H}_2(\text{g})$  and  $\text{CO}_2(\text{g})$  in a 1.00 L container at constant temperature of  $800^\circ\text{C}$ . This equilibrium occurs:



When equilibrium is reached 0.49 mole of  $\text{CO}(\text{g})$  is in the container. Find the value of  $K_c$  and  $K_p$  for the equilibrium.

4. Consider the following equilibrium



Find the equilibrium pressures of all the gases if 10.0 atm of HBr is introduced into a sealed container at 1024 K.

**B: Weak Acids/Bases**

5.a) State the difference between the “Bronsted-Lowry” definition of an acid and base and the “Lewis” definition of an acid and a base.

b) What is the difference between a “strong” and “weak” Bronsted-Lowry acid and base.

6.a) Give the reaction equation for the dissociation of the weak acid HOI in an aqueous solution.

b) Determine the pH of a 2.00 M hypiodous acid, HOI, solution.  $K_a(\text{HOI}) = 2.30 \times 10^{-11}$ .

7. Give the reaction equation for the dissociation of the weak base  $\text{C}_6\text{H}_5\text{NH}_2$  in an aqueous solution.

b) Determine the pH of a 0.200 M aniline,  $\text{C}_6\text{H}_5\text{NH}_2$ , solution.  $K_b(\text{C}_6\text{H}_5\text{NH}_2) = 4.0 \times 10^{-10}$ .



**C: Buffers and Solubility**

8.a) What components must be present in order to have a buffered system? For what purpose are buffers used?

b) Explain why the strong acid hydrochloric acid, HCl, and its conjugate base  $\text{Cl}^-$  would not make a suitable buffer system.

c) What is meant by “exceeding the Buffer capacity” of a buffer system?

9. A 500.0 mL formic acid/formate buffer solution is prepared consisting of 0.400 M  $\text{HCHO}_2$  and 0.300 M  $\text{CHO}_2^-$ .  $K_a = 1.8 \times 10^{-4}$ .

- a) Calculate the pH of the original buffer solution.
- b) Calculate the pH of the resulting solution if 10.0 mL of 5.00 M HCl is added to 500.0 mL of the buffer solution.
- c) Calculate the pH of the resulting solution if 10.0 mL of 5.00 M NaOH is added to 500.0 mL of the buffer solution.
- d) Calculate the pH of the resulting solution if 50.0 mL of 5.00 M HCl is added to 500.0 mL of the buffer solution.

10. For this question do either section a) and b) **or** b), c), and d) for full point value.

Calculate the solubility in moles/liter for the following:

a)  $\text{Al}(\text{OH})_3$ ,  $K_{\text{sp}} = 2 \times 10^{-32}$

b)  $\text{PbCl}_2$ ,  $K_{\text{sp}} = 1.6 \times 10^{-5}$

c)  $\text{PbCl}_2$  in 2.0 M  $\text{NaCl}$ ,  $K_{\text{sp}} = 1.6 \times 10^{-5}$

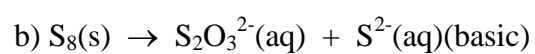
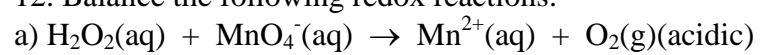
d) Compare your answer for b) and c) and explain the difference.

11. A solution is prepared by mixing 100.0 mL of 0.020 M  $\text{Pb}(\text{NO}_3)_2$  and 100.0 mL of 0.020 M NaCl.  $K_{\text{sp}}(\text{PbCl}_2) = 1.6 \times 10^{-5}$

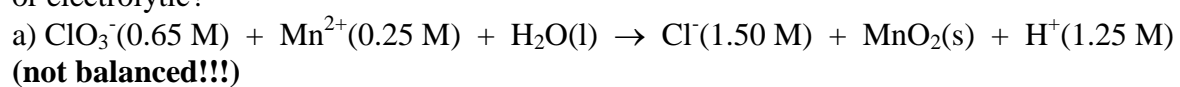
Determine if the solution is unsaturated, saturated, or supersaturated.

**D: Electrochemistry**

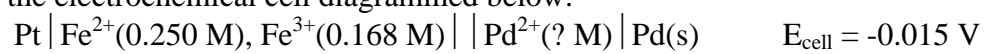
12. Balance the following redox reactions:



13. What is the value of  $E_{\text{cell}}$  for the following electrochemical cells and state if they are voltaic or electrolytic?



14. Given the electrochemical cell diagrammed below.



Calculate the concentration of  $\text{Pd}^{2+}$  in the cell.

**Grade Sheet**

**The points awarded for this exam are outlined below. Please review. If there are any questions or possible corrections please consult the instructor.**

Question	Points Awarded
Part I	
1-6	
Part II	
A	
1-4	
B	
5-7	
C	
8-11	
D	
12-14	
Total	

**Comments:**



## Some Useful Data or Not!

### Constants:

1 kg = 1000 g	$R = 8.314 \text{ kg}\cdot\text{m}^2/\text{s}^2\cdot\text{K}\cdot\text{mole}$
1000 mg = 1 g	$R = 0.0821 \text{ L}\cdot\text{atm}/\text{K}\cdot\text{mole}$
$1 \mu\text{g} = 1\times 10^{-6} \text{ g}$	$R = 8.314 \text{ J}/\text{K}\cdot\text{mole}$
1 mole = $6.022\times 10^{23}$ elementary particles	1 atm = 760 mm Hg = 760 torr
$N_a = 6.0223\times 10^{23}$	1 atm = 101.325 kPa
1 kcal = 4.184 kJ	$K_w = 1.0\times 10^{-14}$
1 kJ = 1000 J	1 F = 96,500 C
1 L = 1000 mL	1 F = 1 mole of electrons
1 nm = $1\times 10^{-9} \text{ m}$	1 A = 1 C/s
1 pm = $1\times 10^{-12} \text{ m}$	1 J = 1 C·V
STP: T = 0°C, P = 1.00 atm	

### Equations:

$$T^{\circ}\text{C} = (5^{\circ}\text{C}/9^{\circ}\text{F})\times(T^{\circ}\text{F} - 32^{\circ}\text{F})$$

$$T(\text{K}) = T(^{\circ}\text{C}) + 273.15^{\circ}\text{C}$$

$$M_1V_1 = M_2V_2$$

$$K_p = K_c(RT)^{\Delta n}$$

$$[\text{H}^+] = 10^{-\text{pH}}$$

$$[\text{OH}^-] = 10^{-\text{pOH}}$$

$$\text{pH} = -\log[\text{H}^+(\text{aq})]$$

$$\text{pH} = -\log[\text{H}_3\text{O}^+]$$

$$\text{pOH} = -\log[\text{OH}^-]$$

$$\text{pOH} + \text{pH} = 14$$

$$K_a \cdot K_b = K_w$$

$$\text{pK}_A = -\log K_A$$

$$\text{pK}_{\text{Hin}} = -\log K_{\text{Hin}}$$

$$K_w = [\text{H}^+(\text{aq})][\text{OH}^-(\text{aq})]$$

$$\text{pH} = \text{pK}_a + \log \frac{[\text{base}]}{[\text{acid}]}$$

$$\text{pH} = \text{pK}_a + \log \frac{\text{moles of base}}{\text{moles of acid}}$$

$$\text{pH} = \text{pK}_{\text{Hin}} + \log \frac{[\text{In}^-]}{[\text{HIn}]}$$

$$\text{For } 0 = ax^2 + bx + c$$

$$X = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$\Delta G^{\circ} = -nFE^{\circ}_{\text{cell}}$$

$$w = nFE_{\text{cell}}$$

$$\Delta G^{\circ} = -RT \ln K$$

$$\Delta G = \Delta G^{\circ} + RT \ln Q$$

$$E = E^{\circ} - \frac{0.0592\text{V}}{n} \log Q$$

**SCRAP PAPER(Do not pass in!!)**

**Answer Set For Chem 1105-Summer Final Exam:****Part I:**

1.b), d), e)

2.a) products, b) products, c) reactants

3.d)

4.a)

5.a) Zr(s); b) H<sub>2</sub>O; c) H<sub>2</sub>O; d) Zr(s)

6.b), c), d)

**Part II:**

1.a)

$$K_c = \frac{[\text{NO(g)}]^2 [\text{Br}_2\text{(g)}]}{[\text{BrNO(g)}]^2}$$

b)

$$K_c = \frac{[\text{CO(g)}]^2}{[\text{CO}_2\text{(g)}]}$$

2. An equilibrium is called a “dynamic process” because reactants are continually being converted into products and likewise products are continually being converted back into reactants. The concentration of reactants and products appears to remain constant because the rate of the forward reaction in which reactants are converted into products equals the rate of the reverse reaction in which products are converted back into reactants.

3.  $K_c = K_p = 0.92$ 4.  $P(\text{H}_2) = P(\text{Br}_2) = 0.026 \text{ atm}$ ,  $P(\text{HBr}) = 10.0 \text{ atm}$ 

5.a) Bronsted-Lowry define acids and bases in regards to the donation and acceptance of protons( $\text{H}^+$ ) while Lewis defines acids and bases in regards to the donation and acceptance of a pair of electrons.

b) A strong Bronsted-Lowry acid and base donate and accept protons completely(100%) while a weak Bronsted-Lowry acid and base only partially donate and accept protons.

6.a)  $\text{HOI(aq)} \rightleftharpoons \text{H}^+\text{(aq)} + \text{OI}^-\text{(aq)}$ 

b) 5.17

7.a)  $\text{C}_6\text{H}_5\text{NH}_2 + \text{H}_2\text{O} \rightleftharpoons \text{C}_6\text{H}_5\text{NH}_3^+ + \text{OH}^-$ 

b) 8.95

8.a) A buffer consists of a weak acid and its conjugate base. A buffer is used to minimize large shifts in pH.

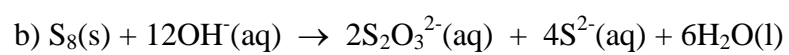
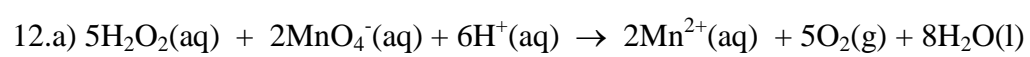
b) HCl and its conjugate base is not a suitable buffer system because HCl is a strong acid and its conjugate base  $\text{Cl}^-$  is too weak to be an effective buffer system.

c) The capacity of a buffer system is exceeded when an added acid or base is added that it completely neutralizes the base or acid component of the buffer system.

9.a) 3.62; b) 3.34; c) 3.87; d) 0.74

10.a)  $5 \times 10^{-9} \text{ M}$ ; b)  $0.016 \text{ M}$ ; c)  $4.0 \times 10^{-6} \text{ M}$ ; d) The solubility decreases for  $\text{PbCl}_2$  in the presence of  $2.0 \text{ M NaCl}$ . A solution of  $2.0 \text{ M Cl}^-$  disturbs the equilibrium and forces it towards the formation of more  $\text{PbCl}_2$  and thus decreases the solubility.

11.a)  $Q = 1.0 \times 10^{-6} < K_{sp}$ . Unsaturated.



13.a) 0.215 V, voltaic; b) 1.73 V, voltaic

14. 0.00122 M