Chem 1105-Final Exam **Instructor: Calvin Howley**
Date: August 10, 2016 **Time Period: 3 hour**

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 in the space provided.

1. Nitric oxide reacts with oxygen to form nitrogen dioxide:

$$2NO(g) + O_2(g) \leftrightharpoons 2NO_2(g)$$

What is K_c' for the **reverse** reaction if the equilibrium concentration of NO is 0.300 M, O_2 is 0.200 M and NO_2 is 0.530 M?

a) 0.0340 b) 0.0641 c) 0.624 d) 15.6

2. If $K_c = 2.0\times10^{33}$ at 25°C, for the following reaction $H_2(g) + Cl_2(g) \leftrightharpoons 2HCl(g)$, then find K_p at the same temperature.

a) 8.2×10^{31} b) 9.7×10^{32} c) 2.0×10^{33} d) 4.9×10^{34}

3. Which equilibrium below is homogeneous?

a) $BaSO_4(s) \leftrightharpoons Ba^{2+}(aq) + SO_4^{2-}(aq)$ b) $2H_2O_2(l) \leftrightharpoons 2H_2O(l) + O_2(g)$

c) $NH_4NO_3(s) \leftrightharpoons N_2O(g) + 2H_2O(g)$ d) $2CO(g) + O_2(g) \leftrightharpoons 2CO_2(g)$

4. An Arrhenius acid is defined as

a) hydroxide donor. b) substance that dissociates in water to produce aqueous hydrogen ions.

c) proton acceptor. d) substance that dissociates in water to produce aqueous hydroxide ions.

5. Indicate **all** the Brønsted-Lowry bases in the following chemical reaction.

$$C_5H_5N + H_2O(l) \leftrightharpoons C_5H_5NH^+(aq) + OH^-(aq)$$

a) C_5H_5N, H_2O b) C_5H_5N, $C_5H_5NH^+$ c) C_5H_5N, OH^- d) C_5H_5N, H_2O, OH^-

6. A solution with a hydroxide ion(OH^-) concentration of 4.15×10^{-4} M is ______________ and has a hydrogen ion(H^+) concentration of ________________.

a) acidic, 2.41×10^{-10} M b) acidic, 2.41×10^{-11} M

c) basic, 2.41×10^{-10} M d) basic, 2.41×10^{-11} M

7. For the galvanic cell $Pt(s)|Sn^{2+}(aq), Sn^{4+}(aq)||Pb^{2+}(aq)|Pb(s)$, what is the function of the Pt(s)?

a) Pt is the anode and is a reactant in the overall cell reaction.

b) Pt is the anode and does not appear in the overall cell reaction.

c) Pt is the cathode and is a product in the overall cell reaction.

d) Pt is the cathode and does not appear in the overall cell reaction.

8. Doubling all the coefficients in the equation for the cell reaction

a) doubles both $E_{cell}°$ and $\Delta G°$. b) doubles $E_{cell}°$, but does not change $\Delta G°$.

c) doubles $\Delta G°$, but does not change $E_{cell}°$. d) does not change $E_{cell}°$ and $\Delta G°$.

9. Based on the following information,

$F_2(g) + 2e^- \rightarrow 2F^-(aq)$ $E° = +2.87$ V
$Mg^{2+}(aq) + 2e^- \rightarrow Mg(s)$ $E° = -2.36$ V

which of the following chemical species is the **strongest reducing agent**?

a) $F_2(g)$ b) $Mg^{2+}(aq)$ c) $F^-(aq)$ d) Mg(s)

Part II: Long Answer
Instructions: Fill your answer in the space provided. Show all work for full point value.
A. Equilibrium

1. Consider the reaction:

$$2H_2S(g) \rightleftharpoons 2H_2(g) + S_2(g) \qquad K_p = 2.4\times10^{-4} \text{ at } 1073 \text{ K}$$

A reaction mixture contains 0.112 atm of H_2, 0.055 atm of S_2, and 0.445 atm of H_2S. Is the reaction mixture at equilibrium? If not, in what direction will the reaction proceed?

2. Consider the reaction:

$$CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g) \qquad K_c = 102 \text{ at } 500 \text{ K}$$

If a reaction mixture initially contains 0.135 M CO and 0.135 M H_2O, what will be the equilibrium concentration of each of the reactants and products?

3. Consider the reaction:

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$$

A reaction mixture in a 5.19 L flask at 30.°C initially contains 2.34 g of H_2 and 26.9 g CO. At equilibrium, the flask contains 8.65 g of CH_3OH. Calculate the equilibrium constants K_c and K_p for the reaction at this temperature.

B. Acid-Base, Buffer, Ksp

4. A 25.0 mL sample of 0.125 M pyridine, a weak base, is titrated with 0.100 M HCl. Calculate the pH at each volume of added acid: 0 mL, 20.00 mL and 40.00 mL.

5. A 100.0 mL buffer solution is 0.175 M in HOCl and 0.150 M in NaOCl.
a) What is the initial pH of this solution?
b) What is the pH after addition of 0.150 g of HBr to the original buffer solution?
c) What is the pH after addition of 0.0850 g of NaOH to the original buffer solution?

6. Calculate the molar solubility of a solution of magnesium hydroxide in pure water? How does this compare to the solubility of $Mg(OH)_2$ in a solution buffered at pH = 10.00? $K_{sp}(Mg(OH)_2) = 2.06\times10^{-13}$

C. Electrochemistry

7. Balance the following redox reactions:

a) $S_2O_3^{2-}(aq) + Cl_2(g) \rightarrow SO_4^{2-}(aq) + Cl^-(aq)$ (acidic)

b) $MnO_4^-(aq) + Br^-(aq) \rightarrow MnO_2(s) + BrO_3^-(aq)$ (basic)

8.a) Calculate E_{cell}^{o} for the following redox reaction:

$$2Ag^{+}(aq) + Ni(s) \rightarrow 2Ag(s) + Ni^{2+}(aq)$$

And state whether or not the reaction is spontaneous or non-spontaneous.

b) The cell potential of the electrochemical cell depends on the gold concentration in the cathode half-cell:

$$Pt(s)\,|\,H_2(1\ atm)\,|\,H^{+}(0.100\ M)\,||\,Au^{+}(?\ M)\,|\,Au(s)$$

What is the concentration of Au^{+} in the cell if E_{cell} is 1.60 V?

9. A current of 11.3A is applied to 1.25 L of a solution of 0.552 M HCl converting some of the H^+ ions into $H_2(g)$ which bubbles out of solution. What is the pH of the original solution? What is the pH of the solution after 73 minutes?

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	
1-9	
Part II	
A	
1-3	
B	
4-6	
C	
7-9	
Total	

Comments:

Some Useful Data or Not!

Constants:

1 mole = 6.022×10^{23} elementary particles
$N_a = 6.0223\times10^{23}$
1000 g = 1 kg
1 g = 1000 mg = 0.001 kg
1 lb = 453.6 g
1 pg = 1×10^{-12} g
1 μg = 1×10^{-6} g
1 km = 1000 m
1 cm = 0.01 m
1 nm = 1×10^{-9}m
1 pm = 1×10^{-12} m
1 μm = 1×10^{-6} m
1 L = 1000 mL

R = 0.0821 L·atm/K·mole
R = 8.314 J/K·mole
R = 8.314 kg·m^2/s^2·K·mole
1 kJ =1000 J
1 cal = 4.184 J
1 atm = 760 mm Hg = 760 torr
1 atm = 101.325 kPa
$K_W = 1.0\times10^{-14}$
1 F = 96,500 C
1 F = 1 mole of electrons
1 A = 1 C/s
1 J = 1 C·V

Equations:

T°C = (5°C/9°F)×(T°F - 32°F)

T(K) = T(°C) + 273.15°C

$M_1V_1 = M_2V_2$

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

$K_a \cdot K_b = K_w$

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

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

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

$pH = -\log[H_3O^+]$

$pOH = -\log[OH^-]$

pOH + pH = 14

$K_w = [H^+(aq)][OH^-(aq)]$

$pK_a = -\log K_a$

$pK_{HIn} = -\text{Log}K_{HIn}$

$$pH = pK_a + \text{Log}\frac{[\text{base}]}{[\text{acid}]}$$

$$pH = pK_a + \text{Log}\frac{\text{moles of base}}{\text{moles of acid}}$$

$w = nF\boldsymbol{E}_{cell}$

$$pH = pK_{HIn} + \text{Log}\frac{[In^-]}{[HIn]}$$

$\Delta G = \Delta G° + RT\ln Q$

$\Delta G° = -nFE°_{cell}$

$\Delta G° = -RT\ln K$

For $0 = ax^2 + bx + c$

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

$$E = E^{o} - \frac{0.0592V}{n}\text{LogQ}$$

<u>SCRAP PAPER(</u>Do not pass in!!)

<u>Answer Set For Chem 1105-Final Exam:</u>

Part I
1.b)

2.c)

3.d)

4.b)

5.c)

6.d)

7. b)

8.c)

9.d)

Part II
1. Q = 0.0035. Q > K_p equilibrium shifts to the left or reactants.

2. [CO] = [H_2O] = 0.012 M, [CO_2] = [H_2] = 0.123 M

3. K_c = 27.6, K_p = 0.0446

4. 9.14, 4.93, 1.87

5.a) 7.33; b) 7.23; c) 7.45

6. In water 3.72×10^{-5} M; for pH = 10.00, 2.06×10^{-5} M

7.a) $S_2O_3^{2-}(aq) + 4Cl_2(g) + 5H_2O(l) \rightarrow 2SO_4^{2-}(aq) + 8Cl^-(aq) + 10H^+(aq)$
b) $2MnO_4^-(aq) + Br^-(aq) + H_2O(l) \rightarrow 2MnO_2(s) + BrO_3^-(aq) + 2OH^-(aq)$

8.a) 1.049 V, spontaneous; b) 0.00302 M

9. 0.26, 0.84