Chem. 1B Midterm 2
Version B
March 3, 2017

Name:_____

Perm Number:_____

All work must be shown on the exam for partial credit. Points will be taken off for incorrect or missing units. Calculators are allowed. Cell phones may not be used as calculators. On fundamental and challenge problems you must show your work in order to receive credit for the problem. If your cell phone goes off during the exam, you will have your exam removed from you.

Fundamentals (of 36 possible)	
Problem 1 (of 20 possible)	
Problem 2 (of 14 possible)	
Multiple Choice (of 30 possible)	
Midterm Total (of 100 possible)	

Fundamental Questions

Each of these fundamental chemistry questions is worth 6 points. You must show work to get credit. Little to no partial credit will be awarded. Make sure to include the correct units on your answers.

1) *6 pts* Use the information on the constant sheet to sort the following chemical species by oxidizing power. 1 will be the species that has the largest oxidizing power and 4 will be the species with the lowest oxidizing power.

Species	Oxidizing Power
$Zn^{2+}(aq)$	3
$Ag^+(aq)$	1 (highest)
$Ni^{2+}(aq)$	2
$Al^{3+}(aq)$	4 (lowest)

2) *6 pts* The rate constant k for a certain reaction is measured at two different temperatures:

temperature	k
104.0°C	4.8×10^3
-36.0 °C	0.023

Assuming the rate constant obeys the Arrhenius equation, calculate the activation energy E_a for this reaction.
Round your answer to 2 significant digits.

$$ln\left(\frac{k_1}{k_2}\right) = \frac{E_a}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)$$

$$ln\left(\frac{4.8 \times 10^3}{0.023}\right) = \frac{E_a}{8.3145 \frac{J}{mol \cdot K}}\left(\frac{1}{237K} - \frac{1}{377K}\right)$$

E_a = 65,000 $\frac{J}{mol}$ = 65 $\frac{kJ}{mol}$

3) *6 pts* Determine the rate law for 2A + B → 2C (you do not need to find the numerical value of k):

Experiment	$[A]_o$ (M)	$[B]_o$ (M)	Initial Rate ($\frac{mol}{L \cdot s}$)
1	0.050	0.10	0.074
2	0.10	0.20	0.888
3	0.050	0.20	0.222

General rate law: $Rate = k[A]^x[B]^y$
Determine Reaction order for A (Experiment 2&3)
      Double [A]   Quadruple rate $Rate = k[A]^2[B]^y$
Determine reaction order for B (Experiment 1&3)

$$\frac{0.074 \frac{mol}{L \cdot s} = k(0.050\,M)^2(0.10\,M)^y}{0.222 \frac{mol}{L \cdot s} = k(0.050\,M)^2(0.20\,M)^y}$$

$$0.333 = \frac{(0.10\,M)^y}{(0.20\,M)^y} = (0.50)^y$$
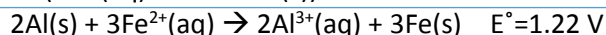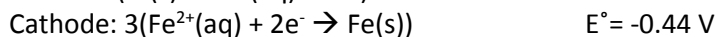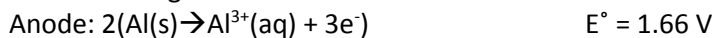
$$log(0.333) = y\,log(0.50)$$

$$y = 1.6$$

$$Rate = k[A]^2[B]^{1.6}$$

4) *6 pts* What is the E_{cell} for the following at 25°C?

$$Al(s)| Al^{3+}(0.18\ M)||Fe^{2+}(0.85\ M)|Fe(s)$$

The reaction occurring in cell

Anode: $2(Al(s) \rightarrow Al^{3+}(aq) + 3e^-)$	E° = 1.66 V
Cathode: $3(Fe^{2+}(aq) + 2e^- \rightarrow Fe(s))$	E°= -0.44 V
$2Al(s) + 3Fe^{2+}(aq) \rightarrow 2Al^{3+}(aq) + 3Fe(s)$	E°=1.22 V

$$E = E° - \frac{RT}{nF}ln(Q) = E° - \frac{RT}{nF}ln\left(\frac{[Al^{3+}]^2}{[Fe^{2+}]^3}\right)$$

$$E = 1.22V - \frac{(8.3145\frac{J}{mol\cdot K})(298K)}{(6)\left(96,485\frac{C}{mol}\right)}ln\left(\frac{0.18^2}{0.85^3}\right) = 1.23V$$

5) *6 pts* Write the overall reaction and rate law that corresponds to the following reaction mechanism. Be sure to eliminate intermediates from the answer.

$$A \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} B+C \qquad \text{fast equilibrium}$$

$$C + D \underset{k_{-2}}{\overset{k_2}{\rightleftharpoons}} E \qquad \text{fast equilibrium}$$

$$E \overset{k_3}{\rightarrow} F \qquad \text{slow}$$
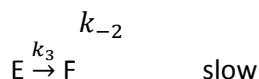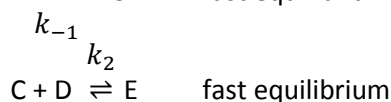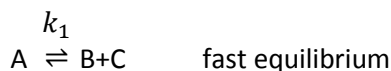
Overall Reaction: $A + D \rightarrow B + F$

$Rate = k_3[E]$

E is an intermediate use equation 2 to eliminate E

$k_2[C][D] = k_{-2}[E]$
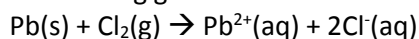
$Rate = \frac{k_2 k_3}{k_{-2}}[C][D]$

C is an intermediate use equation 1 to eliminate C

$k_1[A] = k_{-1}[B][C]$

$Rate = \frac{k_1 k_2 k_3}{k_{-1}k_{-2}}\frac{[A][D]}{[B]}$

6) *6 pts* Draw the following galvanic cell:

$$Pb(s) + Cl_2(g) \rightarrow Pb^{2+}(aq) + 2Cl^-(aq)$$

Calculate E°, show the direction of electron flow and the direction of ion migration through the salt bridge, and identify the cathode and anode.

Anode	Cathode
$Pb \rightarrow Pb^{2+} + 2e^-$	$Cl_2 + 2e^- \rightarrow 2Cl^-$

$Pb \rightarrow Pb^{2+} + 2e^-$ E° = 0.13 V	
$Cl_2 + 2e^- \rightarrow 2Cl^-$ E°=1.36 V	
$Cl_2(g) + Pb(s) \rightarrow Pb^{2+}(aq) + 2Cl^-(aq)$	E°=1.49 V

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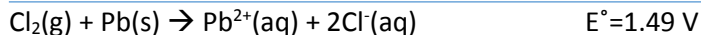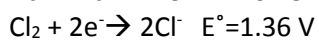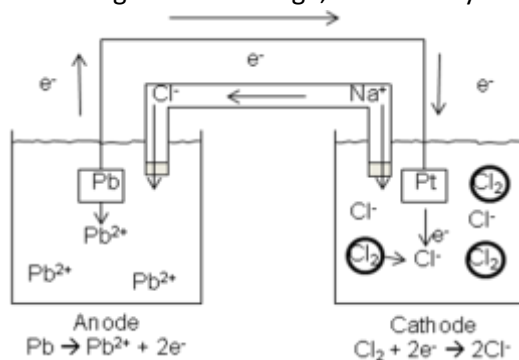
Challenge Problems

Each of the following short answer questions are worth the noted points. Partial credit will be given. You must show your work to get credit. Make sure to include proper units on your answer.

1)   The decomposition of hydrogen peroxide was studied at a particular temperature. The following data were obtained, where

$$rate = -\frac{d[H_2O_2]}{dt}$$

Time (s)	$[H_2O_2]$ (mol/L)
0	1.00
120±1	0.91
300±1	0.78
600±1	0.59
1200±1	0.37
1800±1	0.22
2400±1	0.13
3000±1	0.082
3600±1	0.050

1a)   *8 pts*   Determine the integrated rate law

Find time points that are evenly spaced (0,600,1200,1800)
Determine what give a straight $[H_2O_2]$ vs. t, $\ln[H_2O_2]$ vs. t, or $[H_2O_2]^{-1}$ vs. t

Time (s)	$[H_2O_2]$	$\ln[H_2O_2]$	$\frac{1}{[H_2O_2]}$
0	1.00 (0.41)	0.00 (0.53)	1.00 (-0.69)
600	0.59 (0.22)	-0.53 (0.46)	1.69 (-1.01)
1200	0.37 (0.15)	-0.99 (0.52)	2.70 (-1.85)
1800	0.22	-1.51	4.55

Therefore, the only number that are evenly spaced are the $\ln[H_2O_2]$ so the reaction is 1st order and the integrated rate law is: $ln[H_2O_2] = -kt + ln[H_2O_2]_\circ$

1b)   *2 pts*   Determine the differential rate law.

$Rate = k[H_2O_2]$

1c)   *4 pts*   Determine the value of the rate constant.

Since the reaction was first order with respect to $[O_3]$ the slope of the line equals -k

$$k = -slope = -\frac{rise}{run} = -\frac{ln\left(0.22\,\frac{mol}{L}\right) - ln\left(1.00\,\frac{mol}{cm^3}\right)}{1,800.\ s - 0\ s} = 8.4 \times 10^{-4}\,\frac{1}{s}$$
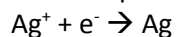
1d)   6 pts   Calculate the $[H_2O_2]$ at 4000. s after the start of the reaction.

$$ln[H_2O_2] = -kt + ln[H_2O_2]_\circ = -\left(8.4 \times 10^{-4}\,\tfrac{1}{s}\right)(4000.\,s) + ln(1.00\ M)$$

$$[H_2O_2] = 0.035\ M$$

2a) *8 pts* Suppose that 2.69 g of a silver salt (AgX) is dissolved in 550. mL of water. With a current of 3.50 A, 395.0 s was needed to plate out all the silver. What is the mass percentage of silver in the salt? (Hint: Silver forms the following ion: Ag^+)

Determine the equation of interest
$$Ag^+ + e^- \rightarrow Ag$$
Determine the moles of e^- and moles of Ag
$$n = \frac{It}{F} = \frac{(3.50\ A)(395.0\ s)}{\left(96{,}485\ \frac{C}{mol}\right)} = 0.0143\ mol\ e^-$$
$$0.0143\ mol\ e^- \left(\frac{1\ mol\ Ag}{1\ mol\ e^-}\right) = 0.0143\ mol\ Ag$$
Determine mass of Ag
$$0.0143\ mol\ Ag \left(\frac{107.87\ g}{1\ mol\ Ag}\right) = 1.54\ g$$
Determine mass Percent
$$mass\ \%\ Ag = \frac{m_{Ag}}{m_{tot}}(100\%) = \frac{1.54\ g}{2.69\ g}(100\%) = 57.2\%$$

2b) *6 pts* What is the formula of the salt?

Determine the identity of X
   For every one mol of Ag there is one mol of X
Determine the molar mass of X
$$M = \frac{m_x}{n_x} = \frac{2.69\ g - 1.54\ g}{0.0143\ mol} = 80.4\ \frac{g}{mol}$$
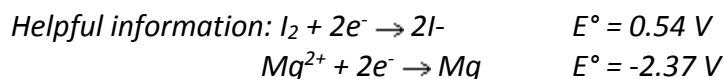Therefore, X is bromine and the formula is AgBr

On the ParScore form you need to fill in your answers, perm number, test version, and name. Failure to do any of these things will result in the loss of 1 point. Your perm number is placed and bubbled in under the "ID number." Do not skip boxes or put in a hyphen; unused boxes should be left blank. Bubble in your test version (B) under the "test form." Note: Your ParScore form will not be returned to you, therefore, for your records, you may want to mark your answers on this sheet. Each multiple choice question is worth 5 points.

1. When the equation $Cl_2 \rightarrow Cl^- + ClO_3^-$ (basic solution) is balanced using the smallest whole-number coefficients, what is the coefficient of OH^-?
   a. 1
   b. 2
   c. 3
   d. 4
   e. None of the above

2. For a reaction in a voltaic cell, both $\Delta H°$ and $\Delta S°$ are positive. Which of the following statements is true?
   a. $E°_{cell}$ will decrease with an increase in temperature.
   b. $E°_{cell}$ will not change when the temperature increases.
   c. $E°_{cell}$ will increase with an increase in temperature.
   d. $\Delta G° > 0$ for all temperatures.
   e. None of the above statements is true.

   An antique automobile bumper is to be chrome plated. The bumper, which is dipped into an acidic $Cr_2O_7^{2-}$ solution, serves as a cathode of an electrolytic cell. The atomic mass of Cr is 51.996; 1 faraday = 96,485 coulombs.
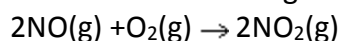
3. If the current is 34.4 amperes, how long will it take to deposit $1.58×10^2$ g of Cr(s) onto the bumper?
   a. 9.5 h
   b. 14.2 h
   c. 23.4 h
   d. 28.4 h
   e. None of the above

4. What reaction occurs at the anode and at the cathode when electrolysis of aqueous MgI_2 occurs? Assume standard conditions.

   Helpful information: $I_2 + 2e^- \rightarrow 2I\text{-}$ $E° = 0.54\ V$

                                 $Mg^{2+} + 2e^- \rightarrow Mg$ $E° = -2.37\ V$

             Anode/Cathode
   a. Magnesium/Water
   b. Iodine/Magnesium
   c. Water/Water
   d. Water/Magnesium
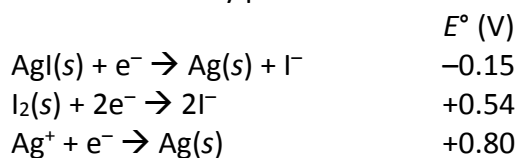   e. None of the above

5. The rate law for the following reaction
           $2NO(g) + O_2(g) \rightarrow 2NO_2(g)$
   was experimentally found to be in the form
           rate=$k[NO]^x[O_2]^y$
   It was also found that when the NO concentration was doubled, the rate of the reaction increases by a factor of 4. In addition, when both the O_2 and the NO concentration were doubled, the rate increases by a factor of 8. What is the reaction order of O_2?

   a. 2nd
   b. 1st
   c. 3rd
   d. 0th
   e. None of the above

6. Calculate the solubility product of silver iodide at 25°C, given the following data:

	$E°$ (V)
$AgI(s) + e^- \rightarrow Ag(s) + I^-$	−0.15
$I_2(s) + 2e^- \rightarrow 2I^-$	+0.54
$Ag^+ + e^- \rightarrow Ag(s)$	+0.80

   a. 2.9×10^{-3}
   b. 8.4×10^{-17}
   c. 3.5×10^{-20}
   d. 1.9×10^{-4}
   e. None of the above

E, C, B, E, B, B