CHEMISTRY 104-4 NAME _____

Spring , 2006, FINAL EXAM **A** Section _____ T.A._____

1. This exam has 11pages, counting the cover sheet and 3 supplementary pages. If a page is missing, take the exam to a proctor immediately.

2. PRINT your name now at the top of this page, and your name or initials at the top of pages 2-8.

3. It will help us if you detach the supplementary sheets.

4. **Show work for all mathematical problems.** If you give a correct answer without showing work points will be deducted. In addition, it will be impossible to assess whether partial credit is deserved if work isn't shown.

5. Give proper **units**, when appropriate. Correct use of **significant figures** is always important.

6. There are 125 points on this exam. The score of this exam will be entered into the grade sheet at Learn@UW. In the final grade calculation, this score will be doubled.

7. The exam must be completed in 120 minutes. Budget your time for each question. Check your work after completing the exam

PLAN FOR 15 OR LESS MINUTES PER PAGE (7 X 15 MIN -- 1 hour 45 min).

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Page 3		/14
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Page 6		/33
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Page 8		/15
Total		/125

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Part I (Organic) 32 pts (16 questions, 2 points each)

1. What hybridization is assigned to the carbonyl carbon of a ketone? _____

2. What is the carbon-carbon bond order in benzene? _____

3. Draw the structure of 3-methyl-4-ethylheptane. Indicate any carbon atom(s) that is/are chiral with an asterisk.

4. Write a balanced chemical equation for the reaction involving addition of H_2O to ethene.

_____

5. Does 2-methyl-2-butene exist as cis- and trans- isomers? _____

6. A breathalyzer is a device that changes color from yellow (from $Cr_2O_7^{2-}$) to grey green (Cr^{3+}) if ethanol is present. What chemical reaction of ethanol is occurring to cause this color change (word answer)?

_____

7. Give the formulas for the products of hydrolysis of ethyl propanoate.

_____ and _____

8. What is the general formula for an aldehyde? _____

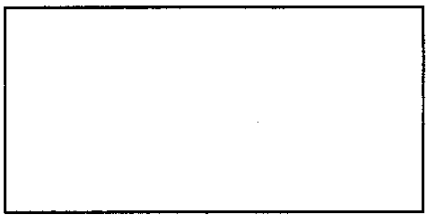
9. The fact that chlorination of methane is initiated by light and gives a mixture of chlorinated products is evidence for what kind of mechanism? _____

10. Write a balanced chemical equation for the polymerization of ethylene.

_____

11. What property of a polymer is a direct consequence of cross-linking of polymer chains? _____

12. Draw the structure of the product of a reaction of benzene with a mixture of nitric and sulfuric acids.

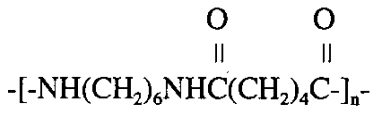


13. Name the product that is formed by reduction (using $LiAlH_4$) of 3-methylbutanal.

_____

14. Give the formulas for the reactants in this polymerization.

_____ + _____ →



$$-[-NH(CH_2)_6NHC(CH_2)_4C-]_n-$$

15. What does the term "primary structure" of a protein describe?

_____

16. You discover an old sample of aspirin that smells like acetic acid. What reaction of aspirin has occurred to form acetic acid?

_____

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Part II. Kinetics and Equilibrium (5 Questions, each worth 6 points)

1. Data for the reaction $2\ NO(g) + 2\ H_2(g) \rightarrow N_2(g) + 2\ H_2O(g)$ are given below:

	[NO]	$[H_2]$	N_2 formation, Initial Rate (mol/L·s)
1.	0.42 M	0.24 M	0.284
2.	0.14 M	0.24 M	0.0315
3.	0.42 M	0.36 M	0.426

a) What is the rate law for this reaction? _____

b) What is the rate constant for the reaction? _____

c) If the rate of formation of N_2 is 0.284 mol/L·s, (in Exp. 1) what is the rate of formation of H_2O? _____

2. The decomposition of $CH_3N{=}NCH_3$ to form C_2H_6 and N_2 is a first order reaction, with a rate constant of 0.289 h^{-1}. What fraction of this compound will remain after 8 hrs?

Fraction _____

3. Which of the statements below about reaction rates and mechanisms are correct? Identify the correct statements by entering T (true) or F (false) in the line.

_____a) In the presence of a catalyst, there are more collisions between reactant molecules.

_____b) At higher temperature a larger fraction of molecules have enough energy to get over the activation energy barrier.

_____c) The average kinetic energy of gaseous reactant molecules depends only on temperature.

_____d) It is possible to predict a rate law for a single step reaction.

_____e) A graph of ln k vs. 1/T will give a straight line.

_____f) It is possible to predict a rate law of a multiple step reaction if the mechanism is known.

4. Ammonia decomposes on heating at 450 °C until equilibrium is reached: $2\ NH_3(g) \rightleftharpoons N_2(g) + 3\ H_2(g)$ A 0.36 mole sample of NH_3 was placed in a 1.0 L flask. At equilibrium, one-third of the NH_3 had decomposed. Calculate equilibrium concentrations of all species; then calculate the equilibrium constant K

	$[NH_3]$, mol/L	N_2[mol/L]	$[H_2]$ mol/L
I	0.36	0	0
C			
E			

K = _____

5. Assume the following system is at equilibrium: $2\ NH_3(g) \rightleftharpoons N_2(g) + 3\ H_2(g)$. A series of stresses are applied; How do $[NH_3]$ and K_e change as the system returns to equilibrium? Write I (increase), D (decrease) or N (no change). The heat of formation of NH_3 from the elements, ΔH_f , is – 45.9 kJ/mol

Stress	Effect on $[NH_3]$	Effect on K_e
a) The volume of the container is increased		
b) The temperature is lowered		
c) More H_2 is added		

Part III. Acids, bases, aqueous equilibrium. 33 pts (11 questions, each worth 3 pts.)

1, List the following bases in order of increasing base strength: H_2O CO_3^{2-} OH^- F^- least_____highest

2. Is the reaction $HF + Ac^- \rightleftharpoons HAc + F^-$ product- or reactant-favored? _____

3. What is the conjugate base of HCO_3^-? _____

4. Is the pH at the equivalence point of a titration of NH_3 with HCl 7 >7 <7 ? _____

5. What is the pH at the half neutralization point in the titration of HAc with NaOH? _____

6. Calculate the pH of a buffer solution composed of 0.50 M $NaHCO_3$ and 0.25 M Na_2CO_3.

pH = _____

7. Write the net ionic equation for the reaction of silver carbonate and HNO_3

_____

8. Identify the least soluble salt among the following:
AgBr $FeCO_3$ $BaSO_4$ CuBr _____

9. Which of the following silver salts is expected to be soluble in HNO_3? Circle all correct answers.
Ag_3PO_4 AgCl AgAc AgI $Ag_2C_2O_4$

10. The solubility of $Co(OH)_2$ is 6.9×10^{-6} mol/L. Calculate its K_{sp}

K_{sp} = _____

11. What equilibrium constants are needed to calculation the equilibrium constant for the reaction $AgCN + CN^- \rightleftharpoons Ag(CN)_2^-$?

_____

Part IV. Electrochemistry (6 questions, each worth 5 points)

1. Write a balanced equation for the following redox reaction:

$$Zn + NO_3^- \rightarrow Zn^{2+} + N_2O \qquad \text{in acid solution}$$

2. In a voltaic cell made up of Zn/Zn^{2+} and Ag/Ag^+ half cells. Identify:

which metal is the anode _____

the reaction occurring at the cathode _____

the direction of electron flow
in the external circuit from _____ half-cell to _____ half cell

the direction of negative ion flow
in the salt bridge from _____ half-cell to _____ half cell

the cell reaction (net equation) _____

3. a) (2) Calculate the standard potential of the cell in Q2.

$E° =$ _____

b) (3) Calculate the cell voltage, if $[Zn^{2+}] = 0.50$ M and $[Ag^+] = 1.0 \times 10^{-5}$ M.

$E =$ _____

4. Predict the following (use the table of SRP), Circle all correct answers, more than one answer is possible for some questions.

Which metals will react with H^+	Mg	Cu	Ag	Al
Which is the strongest oxidizing agent	H^+	Ag^+	Zn^{2+}	Sn^{4+}
Species that will reduce Cu^{2+} to Cu	Fe	I^-	H_2	Cl_2
Easiest halide ion to oxidize	F^-	Cl^-	Br^-	I^-

$Cl_2 + 2\ Br^- \rightleftharpoons 2Cl^- + Br_2$ product-favored or reactant-favored

5. a) (2) What is the overall cell reaction using the following two half-reactions.

cathode: $2\ H_2O + 2\ e^- \rightleftharpoons H_2 + 2OH^-$ E = - 0.828 V
anode: $H_2 \rightleftharpoons 2\ H^+ + 2\ e^-$ E = 0.0 V

_____

b) (3) What is the equilibrium constant for a reaction?

K = _____

6. In the electrolysis of $CuBr_2(aq)$ to electroplate copper:

a) (2) What is the anode reaction? _____

b) (2) What is the minimum voltage required for electrolysis to occur? _____

c) (1) If 1.00 Faradays (96,500 amp sec) of current is consumed how much copper metal will be formed?

_____

Table 17.3 • Ionization Constants for Some Acids and Their Conjugate Bases

Acid Name	Acid	K_a	Base	K_b	Base Name
Perchloric acid	$HClO_4$	large	ClO_4^-	very small	perchlorate ion
Sulfuric acid	H_2SO_4	large	HSO_4^-	very small	hydrogen sulfate ion
Hydrochloric acid	HCl	large	Cl^-	very small	chloride ion
Nitric acid	HNO_3	large	NO_3^-	very small	nitrate ion
Hydronium ion	H_3O^+	1.0	H_2O	1.0×10^{-14}	water
Sulfurous acid	H_2SO_3	1.2×10^{-2}	HSO_3^-	8.3×10^{-13}	hydrogen sulfite ion
Hydrogen sulfate ion	HSO_4^-	1.2×10^{-2}	SO_4^{2-}	8.3×10^{-13}	sulfate ion
Phosphoric acid	H_3PO_4	7.5×10^{-3}	$H_2PO_4^-$	1.3×10^{-12}	dihydrogen phosphate ion
Hexaaquairon(III) ion	$Fe(H_2O)_6^{3+}$	6.3×10^{-3}	$Fe(H_2O)_5OH^{2+}$	1.6×10^{-12}	pentaaquahydroxoiron(III) ion
Hydrofluoric acid	HF	7.2×10^{-4}	F^-	1.4×10^{-11}	fluoride ion
Nitrous acid	HNO_2	4.5×10^{-4}	NO_2^-	2.2×10^{-11}	nitrite ion
Formic acid	HCO_2H	1.8×10^{-4}	HCO_2^-	5.6×10^{-11}	formate ion
Benzoic acid	$C_6H_5CO_2H$	6.3×10^{-5}	$C_6H_5CO_2^-$	1.6×10^{-10}	benzoate ion
Acetic acid	CH_3CO_2H	1.8×10^{-5}	$CH_3CO_2^-$	5.6×10^{-10}	acetate ion
Propanoic acid	$CH_3CH_2CO_2H$	1.3×10^{-5}	$CH_3CH_2CO_2^-$	7.7×10^{-10}	propanoate ion
Hexaaquaaluminum ion	$Al(H_2O)_6^{3+}$	7.9×10^{-6}	$Al(H_2O)_5OH^{2+}$	1.3×10^{-9}	pentaaquahydroxoaluminum ion
Carbonic acid	H_2CO_3	4.2×10^{-7}	HCO_3^-	2.4×10^{-8}	hydrogen carbonate ion
Hexaaquacopper(II) ion	$Cu(H_2O)_6^{2+}$	1.6×10^{-7}	$Cu(H_2O)_5OH^+$	6.25×10^{-8}	pentaaquahydroxocopper(II) ion
Hydrogen sulfide	H_2S	1×10^{-7}	HS^-	1×10^{-7}	hydrogen sulfide ion
Dihydrogen phosphate ion	$H_2PO_4^-$	6.2×10^{-8}	HPO_4^{2-}	1.6×10^{-7}	hydrogen phosphate ion
Hydrogen sulfite ion	HSO_3^-	6.2×10^{-8}	SO_3^{2-}	1.6×10^{-7}	sulfite ion
Hypochlorous acid	HClO	3.5×10^{-8}	ClO^-	2.9×10^{-7}	hypochlorite ion
Hexaaqualead(II) ion	$Pb(H_2O)_6^{2+}$	1.5×10^{-8}	$Pb(H_2O)_5OH^+$	6.7×10^{-7}	pentaaquahydroxolead(II) ion
Hexaaquacobalt(II) ion	$Co(H_2O)_6^{2+}$	1.3×10^{-9}	$Co(H_2O)_5OH^+$	7.7×10^{-6}	pentaaquahydroxocobalt(II) ion
Boric acid	$B(OH)_3(H_2O)$	7.3×10^{-10}	$B(OH)_4^-$	1.4×10^{-5}	tetrahydroxoborate ion
Ammonium ion	NH_4^+	5.6×10^{-10}	NH_3	1.8×10^{-5}	ammonia
Hydrocyanic acid	HCN	4.0×10^{-10}	CN^-	2.5×10^{-5}	cyanide ion
Hexaaquairon(II) ion	$Fe(H_2O)_6^{2+}$	3.2×10^{-10}	$Fe(H_2O)_5OH^+$	3.1×10^{-5}	pentaaquahydroxoiron(II) ion
Hydrogen carbonate ion	HCO_3^-	4.8×10^{-11}	CO_3^{2-}	2.1×10^{-4}	carbonate ion
Hexaaquanickel(II) ion	$Ni(H_2O)_6^{2+}$	2.5×10^{-11}	$Ni(H_2O)_5OH^+$	4.0×10^{-4}	pentaaquahydroxonickel(II) ion
Hydrogen phosphate ion	HPO_4^{2-}	3.6×10^{-13}	PO_4^{3-}	2.8×10^{-2}	phosphate ion
Water	H_2O	1.0×10^{-14}	OH^-	1.0	hydroxide ion
Hydrogen sulfide ion*	HS^-	1×10^{-19}	S^{2-}	1×10^5	sulfide ion
Ethanol	C_2H_5OH	very small	$C_2H_5O^-$	large	ethoxide ion
Ammonia	NH_3	very small	NH_2^-	large	amide ion
Hydrogen	H_2	very small	H^-	large	hydride ion

Increasing Acid Strength ↑

Increasing Base Strength ↑

*The values of K_a for HS^- and K_b for S^{2-} are estimates.

Solubility Product Constants for Some Inorganic Compounds at 25 °C

Table 18A • Solubility Product Constants (25 °C)

Cation	Compound	K_{sp}	Cation	Compound	K_{sp}
Ba^{2+}	*$BaCrO_4$	1.2×10^{-10}	Mg^{2+}	$MgCO_3$	6.8×10^{-6}
	$BaCO_3$	2.6×10^{-9}		MgF_2	5.2×10^{-11}
	BaF_2	1.8×10^{-7}		$Mg(OH)_2$	5.6×10^{-12}
	*$BaSO_4$	1.1×10^{-10}			
			Mn^{2+}	$MnCO_3$	2.3×10^{-11}
Ca^{2+}	$CaCO_3$ (calcite)	3.4×10^{-9}		*$Mn(OH)_2$	1.9×10^{-13}
	*CaF_2	5.3×10^{-11}			
	*$Ca(OH)_2$	5.5×10^{-5}	Hg_2^{2+}	*Hg_2Br_2	6.4×10^{-23}
	$CaSO_4$	4.9×10^{-5}		Hg_2Cl_2	1.4×10^{-18}
				*Hg_2I_2	2.9×10^{-29}
$Cu^{+,2+}$	$CuBr$	6.3×10^{-9}		Hg_2SO_4	6.5×10^{-7}
	CuI	1.3×10^{-12}			
	$Cu(OH)_2$	2.2×10^{-20}	Ni^{2+}	$NiCO_3$	1.4×10^{-7}
	$CuSCN$	1.8×10^{-13}		$Ni(OH)_2$	5.5×10^{-16}
Au^+	$AuCl$	2.0×10^{-13}	Ag^+	*$AgBr$	5.4×10^{-13}
				*$AgBrO_3$	5.4×10^{-5}
Fe^{2+}	$FeCO_3$	3.1×10^{-11}		$AgCH_3CO_2$	1.9×10^{-3}
	$Fe(OH)_2$	4.9×10^{-17}		$AgCN$	6.0×10^{-17}
				Ag_2CO_3	8.5×10^{-12}
Pb^{2+}	$PbBr_2$	6.6×10^{-6}		*$Ag_2C_2O_4$	5.4×10^{-12}
	$PbCO_3$	7.4×10^{-14}		*$AgCl$	1.8×10^{-10}
	$PbCl_2$	1.7×10^{-5}		Ag_2CrO_4	1.1×10^{-12}
	$PbCrO_4$	2.8×10^{-13}		*AgI	8.5×10^{-17}
	PbF_2	3.3×10^{-8}		$AgSCN$	1.0×10^{-12}
	PbI_2	9.8×10^{-9}		*Ag_2SO_4	1.2×10^{-5}
	$Pb(OH)_2$	1.4×10^{-15}			
	$PbSO_4$	2.5×10^{-8}			

(continued)

Table 18B • K_{spa} Values* for Some Metal Sulfides (25 °C)

Substance	K_{spa}
HgS (red)	4×10^{-54}
HgS (black)	2×10^{-53}
Ag_2S	6×10^{-51}
CuS	6×10^{-37}
PbS	3×10^{-28}
CdS	8×10^{-28}
SnS	1×10^{-26}
FeS	6×10^{-19}

Cation	Compound	K_{sp}	Cation	Compound	K_{sp}
Sr^{2+}	$SrCO_3$	5.6×10^{-10}	Zn^{2+}	$Zn(OH)_2$	3×10^{-17}
	SrF_2	4.3×10^{-9}		$Zn(CN)_2$	8.0×10^{-12}
	$SrSO_4$	3.4×10^{-7}			
Tl^+	$TlBr$	3.7×10^{-6}			
	$TlCl$	1.9×10^{-4}			
	TlI	5.5×10^{-8}			

Table 20.1 • Standard Reduction Potentials in Aqueous Solution at 25 °C*

Reduction Half-Reaction		$E°$ (V)
$F_2(g) + 2\ e^-$	$\longrightarrow 2\ F^-(aq)$	+2.87
$H_2O_2(aq) + 2\ H^+(aq) + 2\ e^-$	$\longrightarrow 2\ H_2O(\ell)$	+1.77
$PbO_2(s) + SO_4^{2-}(aq) + 4\ H^+(aq) + 2\ e^-$	$\longrightarrow PbSO_4(s) + 2\ H_2O(\ell)$	+1.685
$MnO_4^-(aq) + 8\ H^+(aq) + 5\ e^-$	$\longrightarrow Mn^{2+}(aq) + 4\ H_2O(\ell)$	+1.52
$Au^{3+}(aq) + 3\ e^-$	$\longrightarrow Au(s)$	+1.50
$Cl_2(g) + 2\ e^-$	$\longrightarrow 2\ Cl^-(aq)$	+1.360
$Cr_2O_7^{2-}(aq) + 14\ H^+(aq) + 6\ e^-$	$\longrightarrow 2\ Cr^{3+}(aq) + 7\ H_2O\ (\ell)$	+1.33
$O_2(g) + 4\ H^+(aq) + 4\ e^-$	$\longrightarrow 2\ H_2O(\ell)$	+1.229
$Br_2(\ell) + 2\ e^-$	$\longrightarrow 2\ Br^-(aq)$	+1.08
$NO_3^-(aq) + 4\ H^+(aq) + 3\ e^-$	$\longrightarrow NO(g) + 2\ H_2O(\ell)$	+0.96
$OCl^-(aq) + H_2O(\ell) + 2\ e$	$\longrightarrow Cl^-(aq) + 2\ OH^-(aq)$	+0.89
$Hg^{2+}(aq) + 2\ e^-$	$\longrightarrow Hg(\ell)$	+0.855
$Ag^+(aq) + e^-$	$\longrightarrow Ag(s)$	+0.80
$Hg_2^{2+}(aq) + 2\ e^-$	$\longrightarrow 2\ Hg(\ell)$	+0.789
$Fe^{3+}(aq) + e^-$	$\longrightarrow Fe^{2+}(aq)$	+0.771
$I_2(s) + 2\ e^-$	$\longrightarrow 2\ I^-(aq)$	+0.535
$O_2(g) + 2\ H_2O(\ell) + 4\ e^-$	$\longrightarrow 4\ OH^-(aq)$	+0.40
$Cu^{2+}(aq) + 2\ e^-$	$\longrightarrow Cu(s)$	+0.337
$Sn^{4+}(aq) + 2\ e^-$	$\longrightarrow Sn^{2+}(aq)$	+0.15
$2\ H^+(aq) + 2\ e^-$	$\longrightarrow H_2(g)$	0.00
$Sn^{2+}(aq) + 2\ e^-$	$\longrightarrow Sn(s)$	−0.14
$Ni^{2+}(aq) + 2\ e^-$	$\longrightarrow Ni(s)$	−0.25
$V^{3+}(aq) + e^-$	$\longrightarrow V^{2+}(aq)$	−0.255
$PbSO_4(s) + 2\ e^-$	$\longrightarrow Pb(s) + SO_4^{2-}(aq)$	−0.356
$Cd^{2+}(aq) + 2\ e^-$	$\longrightarrow Cd(s)$	−0.40
$Fe^{2+}(aq) + 2\ e^-$	$\longrightarrow Fe(s)$	−0.44
$Zn^{2+}(aq) + 2\ e^-$	$\longrightarrow Zn(s)$	−0.763
$2\ H_2O(\ell) + 2\ e^-$	$\longrightarrow H_2(g) + 2\ OH^-(aq)$	−0.8277
$Al^{3+}(aq) + 3\ e^-$	$\longrightarrow Al(s)$	−1.66
$Mg^{2+}(aq) + 2\ e^-$	$\longrightarrow Mg(s)$	−2.37
$Na^+(aq) + e^-$	$\longrightarrow Na(s)$	−2.714
$K^+(aq) + e^-$	$\longrightarrow K(s)$	−2.925
$Li^+(aq) + e^-$	$\longrightarrow Li(s)$	−3.045