

Name \_\_\_\_\_

4 August 2005

**CHM 112 Final Exam (150 pts total)**

**Tables of data and equations are on the last pages of the exam.**

(1.) Methanol (CH<sub>3</sub>OH) is manufactured by the reaction of carbon monoxide with hydrogen in the presence of a ZnO/Cr<sub>2</sub>O<sub>3</sub> catalyst:



Does the amount of methanol increase, decrease, or remain the same when an equilibrium mixture of reactants and products is subjected to the following changes? (15 pts)

(a) The temperature is increased

(b) The volume is decreased

(c) Helium is added

(d) The catalyst is removed

(2.) Consider the list of acids:

(10 pts.)

Acid	$K_a$
$\text{CH}_3\text{COOH}$	$1.8 \times 10^{-5}$
$\text{HNO}_2$	$5.1 \times 10^{-4}$
$\text{CHCl}_2\text{COOH}$	$5.0 \times 10^{-2}$
$\text{HOCl}$	$2.9 \times 10^{-8}$

Which acid has the strongest conjugate base? Write the Lewis structure for this base.

Write the reaction of this base with water. Would the pH of this conjugate base be greater than or less than 7? What effect causes the third acid to be much stronger than the first acid?

(3.) The solubility of silver chromate,  $\text{Ag}_2\text{CrO}_4$ , is  $7.95 \times 10^{-5}$  M. What is the equilibrium constant (or solubility product) for dissolving silver chromate?

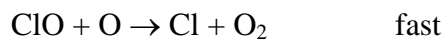
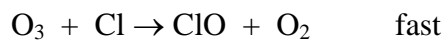
(5 pts)

(4.) What is the pH of a solution prepared from 3.52 g of aniline (a weak base),  $\text{C}_6\text{H}_5\text{NH}_2$ , and 200 mL of water?

(15pts)

(5.) You may have heard of the “ozone hole” in the atmosphere. A mechanism for the destruction of ozone ( $\text{O}_3$ ) is:

(15 pts)



Write the balanced equation for this mechanism.

Write the rate law.

What are the intermediates (if any)?

What are the catalysts (if any)?

(6.) Which of the following solutions will have the lowest freezing point? Support your answer with a calculation. Assume the volumes of the solutions are the same.

- a. 1 m NaCl (aq) (10pts.)
- b. 1 m CaBr<sub>2</sub> (aq)
- c. 1 m Al(NO<sub>3</sub>)<sub>3</sub> (aq)

(7.) Identify the types of intermolecular forces that are present in each of the following substances and select the substance in each pair that has the higher boiling point. (10 pts)

a.  $C_6H_{14}$  or  $C_8H_{18}$

b.  $C_3H_8$  or  $CH_3OCH_3$

c.  $CH_3OH$  or  $CH_3SH$

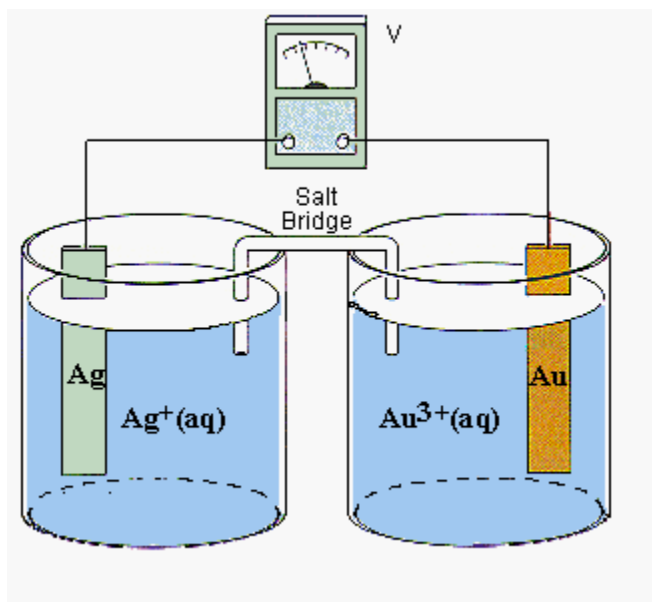
d.  $NH_2NH_2$  or  $CH_3CH_3$

(8.) 0.137 g of an unknown enzyme was dissolved in water to make 125.0 mL of solution. The osmotic pressure was determined to be 5.744 mm Hg at  $37^\circ C$ . What is the molar mass of the enzyme?

(10 pts)

(9.) Consider the electrochemical cell shown below:

(20pts)



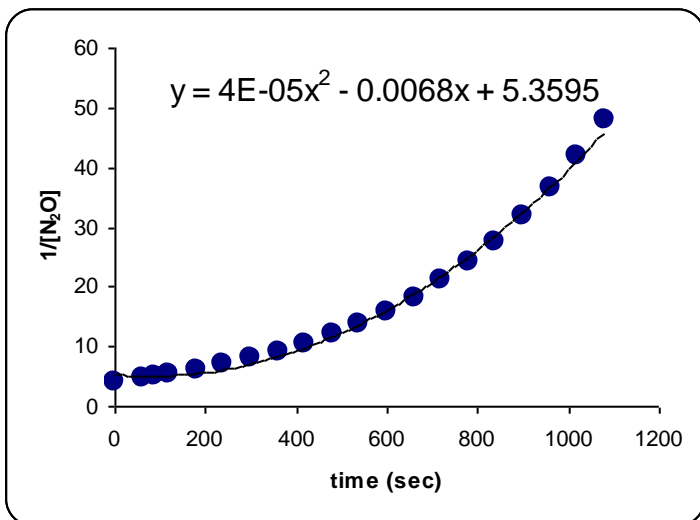
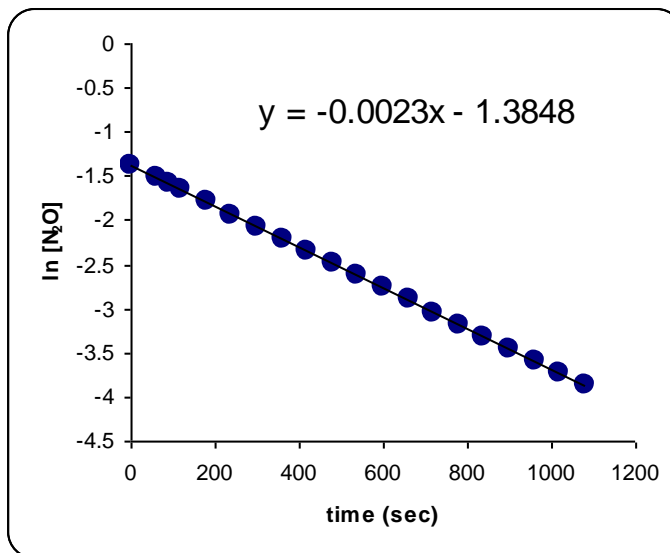
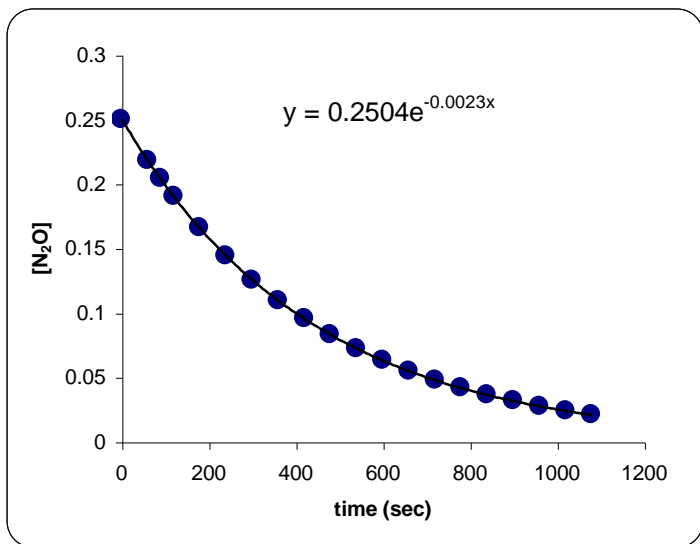
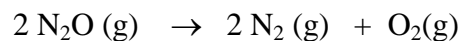
The standard reduction potential,  $E^\circ$ , of  $\text{Ag}^+$  to Ag metal is 0.7996 V, and the reduction potential,  $E^\circ$ , of  $\text{Au}^{3+}$  to Au metal is 1.52 V.

1. Write the half reactions and the balanced equation for the reaction between Au and  $\text{Ag}^+$ .
2. How many electrons are transferred in this reaction?
3. Is the reaction spontaneous as written?
4. Write the reaction in the direction of spontaneous change (the way it would really go).



(10.) At elevated temperatures, nitrous oxide decomposes according to the equation:

(15 pts)



(a) Use the plots to determine the order, the value of  $k$  and the half-life ( $t_{1/2}$ )

(b) Write the rate law for the reaction

(c) What is the initial concentration of  $\text{N}_2\text{O}$ ? {given the answer to 4 decimal places}

*Please use the reverse side of this page for your answer.*

**(11.)** Formic acid ( $\text{HCO}_2\text{H}$ ) is an organic acid secreted by ants. Calculate the pH and the concentrations of all species present ( $\text{HCO}_2\text{H}$ ,  $\text{HCO}_2^-$ ,  $\text{H}_3\text{O}^+$ , and  $\text{OH}^-$ ) in 0.20 M  $\text{HCO}_2\text{H}$ . Also calculate the % dissociation. (10 pts)

**(12.)** Calculate the pH of a solution that contains 0.20 M formic acid and 0.50 M sodium formate. (5 pts)

(13.) Describe the three definitions of acids and bases (with examples) (10 pts)

(a) **Arrhenius** Acids & Bases

(b) **Brønsted-Lowry** Acids & Bases

(c) **Lewis** Acids and Bases

**Relative Atomic Masses** Table

1.00797 **H** 4.00260 **He**

6.941 **Li** 9.01218 **Be**
□ Gas ■ Liquid ■ Synthesised ■ Solid

<b>Transition Elements</b>										10.811	12.011	14.007	15.999	18.998	20.180		
22.990	24.305											26.982	28.086	30.974	32.066	35.453	39.948
39.098	40.078	44.956	47.88	50.942	51.996	54.938	55.847	58.933	58.693	63.546	65.39	69.723	72.61	74.922	78.96	79.904	83.80
85.468	87.62	88.906	91.224	92.906	95.94	97.907	101.07	102.91	106.42	107.87	112.41	114.82	118.71	121.76	127.60	126.90	131.29
132.91	137.36	138.91	178.49	180.95	183.84	186.21	190.23	192.22	195.08	196.97	200.59	204.38	207.20	208.98	208.98	209.99	222.02
223.02	226.03	227.03	261.11	262.11	263.12	262.12	265.13	266	269	272	277						
Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt	Uun	Uuu	Uub						
												Halogens			Noble Gases		
Alkali Metals			Lanthanides (Rare Earths)														
			140.12	140.91	144.24	144.91	150.36	151.96	157.25	158.93	162.50	164.93	167.26	168.93	173.04	174.97	
			Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	
			232.04	231.04	238.03	237.05	244.06	243.06	245	247.07	251.08	252.08	257.10	258.10	259.10	262.11	
			Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr	
			Actinides														

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$$\Delta T_f = k_m m$$

$$\Delta T_f = nk_m m$$

$$\Delta T_b = k_b m$$

$$\Delta T_b = nk_b m$$

$$\Pi = RTM$$

$$\Pi = nRTM$$

$$P_{soln} = \chi_{solv} \cdot P_{solv}$$

$$\chi_i = \frac{\text{moles}_i}{\text{total}_\text{moles}}$$

$$\ln[A] - \ln[A]_o = -kt$$

$$t_{1/2} = \frac{\ln 2}{k}$$

$$\frac{1}{[A]} - \frac{1}{[A]_o} = kt$$

$$\ln k = \ln A - \frac{E_a}{R} \frac{1}{T}$$

$$\frac{\bar{v}_{D1}}{\bar{v}_{D2}} = \sqrt{\frac{m_2}{m_1}} \quad \bar{v}_{RMV} = \sqrt{\frac{3000RT}{mm(g \cdot mol^{-1})}} \text{ or } \sqrt{\frac{3RT}{mm(kg \cdot mol^{-1})}}$$

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

$$\Delta G^\circ = -nFE^\circ$$

$$\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$$

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

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

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

$$\text{pK}_a + \text{pK}_b = 14$$

$$[\text{H}_3\text{O}^+][\text{OH}^-] = 1 \times 10^{-14}$$

$$\text{pH} = \text{pK}_a + \log \frac{[\text{A}^-]}{[\text{HA}]}$$

Acid Dissociation Constants*	
	pKa
Ammonia, $\text{NH}_3\mathbf{H}^+$ (aka $\text{NH}_4^+$ )	4.75
Aniline, $\text{C}_6\text{H}_5\text{NH}_2\mathbf{H}^+$	4.60
Formic acid, $\text{HCO}_2\mathbf{H}$	3.74

\* Each acid is written in its protonated form. The acidic protons are indicated in bold type.

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$$K_f(\text{H}_2\text{O}) = -1.86 \text{ K/molal}$$

$$K_b(\text{H}_2\text{O}) = 0.512 \text{ K/molal}$$

$$R = 0.0821 \text{ L atm mol}^{-1}\text{K}^{-1}$$

$$R = 8.314 \text{ J mol}^{-1}\text{K}^{-1}$$