

LAST NAME: _____

FIRST NAME: _____

Student Number: _____

CHM 1311 A Midterm #2 A Fall 2011

Please keep your work covered at all times and keep your eyes on your own paper! Cheating or any appearance of cheating will result in an F in the course and possible expulsion from the university.

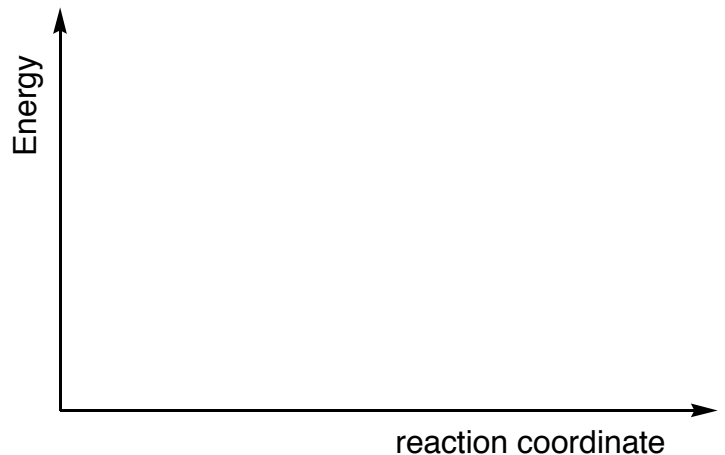
There are 10 pages in this test. A periodic table and data sheets are provided at the end. You may rip these pages off of the exam and use them to cover your work during the test. Any scratch work should be done on the back of these pages.

Please show all work to receive partial credit.

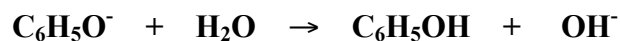
You have 75 minutes to complete the test.

1. (20 points) Short Answer Questions

- a. The chemical reaction $A + B \rightarrow C$ was determined to be a fairly slow reaction and significantly exothermic. On the axes provided at right, draw a representative reaction profile for this reaction.



- b. The value of K_b for the reaction below is : _____.



- c. Which of the following compounds is categorized as insoluble?



- d. Sodium nitrite is dissolved in water. The pH of the resulting solution will be

NEUTRAL **ACIDIC** **BASIC**

- e. According to collision theory, when two species collide to react to form products, they must fulfill the following two requirements:

(i) _____

(ii) _____

- f. The equilibrium constant expression for the dissolution of $\text{Cu}(\text{OH})_2$ is:

$$K_{sp} = \underline{\hspace{10em}}$$

The solubility of this compound will increase in acidic solution. **TRUE** **FALSE**

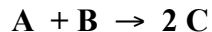
- g. The conjugate acid and base of HCO_3^- are _____ and _____, respectively.

2. (10 points) Magnesium hydroxide is a poorly soluble compound.

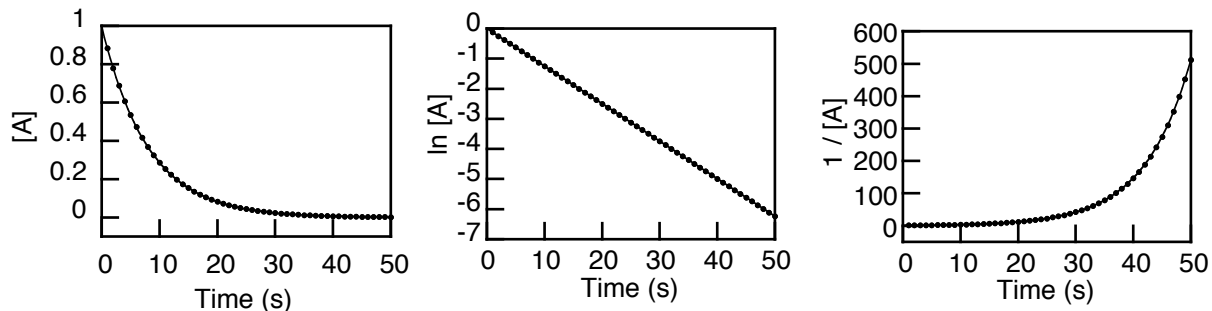
a) What is the pH of a saturated $\text{Mg}(\text{OH})_2$ aqueous solution?

b) 25.00 mL of an unstandardized solution of HCl (aq) is titrated with the aqueous solution of part (a). If 13.08 mL of titrant is added to reach the endpoint, what is the concentration of HCl?

3. (10 points). The progress of the reaction below is followed for 50 seconds.



The following graphs are made using the experimental data:



a) According to the graphs, what is the order of the rate-determining step? _____

b) It is believed that the reaction occurs via a 2-step mechanism, with "I" as a reaction intermediate, formed in the first step. Propose a viable mechanism, and indicate the RDS.

c) What is the value of the rate constant for the RDS?

Answer: _____

d) What will [A] be after 30 seconds, if its initial concentration is 0.550 M?

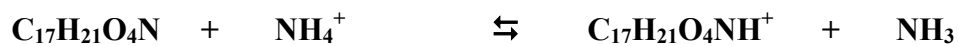
Answer: _____

4. (10 points) You mix a 50.0 mL sample of 0.0152M $\text{Na}_2\text{S}(\text{aq})$ with a 50.0 mL sample of 0.0125M $\text{Zn}(\text{NO}_3)_2(\text{aq})$. You observe the formation of a precipitate.
- a) Propose a complete balanced chemical equation for this process.
- b) Propose a net ionic reaction for what occurred in this process.
- c) What percentages of Na^+ and Zn^{2+} remain unprecipitated? (You may assume that the volumes are additive)

5. (10 points) Alkaloids are compounds noted for their bitter taste, an indication of their basic properties. One alkaloid, $C_{17}H_{21}O_4N$ (MW = 303.348 g/mol) has an aqueous solubility of 0.17 g/100 mL.

a) A saturated solution of this compound has a pH = 10.08. What is the value of K_b ?

b) Ammonia, NH_3 , has a K_b of 1.8×10^{-5} . On the equilibrium below, label the acid, base, conjugate acid and conjugate base, and predict the preferred direction of the reaction (i.e. towards reactants or products?). To obtain full marks, show your reasoning.



Answer: _____

Gas Laws

$$PV = nRT$$

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$P_T = P_1 + P_2 + P_3 + \dots$$

$$P_A = \chi_A P_T$$

$$d = \frac{m}{V} = \frac{P \cdot MM}{RT}$$

$$E_K = \frac{1}{2}mv^2$$

$$u_{rms} = \sqrt{\frac{3RT}{MM}}$$

$$\frac{\text{Rate A}}{\text{Rate B}} = \sqrt{\frac{MM_B}{MM_A}}$$

$$\left(P + \frac{n^2a}{V^2}\right)(V - nb) = nRT$$

Equilibrium

$$K_P = K_C(RT)^{\Delta n}$$

Acid/Base

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

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

$$pH + pOH = 14$$

$$K_a \times K_b = K_w$$

$$pH = pK_a + \log \frac{[A^-]}{[HA]}$$

$$pH = \frac{pK_{a1} + pK_{a2}}{2}$$

Thermochemistry

$$\Delta U = q + W$$

$$W_{\text{system}} = -P\Delta V = -\Delta nRT$$

$$\Delta H = \Delta U + P\Delta V$$

$$q_p = \Delta U + P\Delta V$$

$$q = ms\Delta T$$

$$q = n\Delta H$$

$$\Delta H_{\text{rxn}}^\circ = \sum n\Delta H_f^\circ(\text{pds}) - \sum n\Delta H_f^\circ(\text{rxts})$$

The atom

$$E = h\nu$$

$$c = \nu\lambda$$

$$E = -B/n^2$$

Kinetics

$$[A]_t = [A]_o - kt$$

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

$$1/[A]_t = 1/[A]_o + kt$$

$$k = Ae^{(-E_a/RT)}$$

$$\ln(k_2/k_1) = (-E_a/R)(1/T_2 - 1/T_1)$$

Other

$$n = m/MM$$

$$C = n/V$$

$$\% \text{yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100\%$$

$$\chi_A = \frac{n_A}{n_T}$$

Data For Water

Density = 1.00 g/mL (at 25°C)

 $s = 2.13 \text{ J g}^{-1} \text{ K}^{-1}$ (solid) $s = 4.184 \text{ J g}^{-1} \text{ K}^{-1}$ (liquid) $s = 2.01 \text{ J g}^{-1} \text{ K}^{-1}$ (gas) $\Delta H^\circ_{\text{fus}} = 6.02 \text{ kJ mol}^{-1}$ $\Delta H^\circ_{\text{vap}} = 40.7 \text{ kJ mol}^{-1}$ **Constants and Conversion Factors**

1 mmHg = 1 torr 760 mmHg = 1 atm 1 atm = 101.325 kPa 1 atm = 1.013125 bar
 1 cm³ = 1 mL 1000 mL = 1 L 1000 L = 1 m³

Avogadro's Number	N	$6.022 \times 10^{23} \text{ mol}^{-1}$	
Boltzmann's constant	k	$1.30866 \times 10^{-23} \text{ J} \cdot \text{K}^{-1}$	
Faraday's constant	F	$96,485 \text{ C} \cdot \text{mol}^{-1}$	
Gas constant	R	$8.31451 \text{ J} \cdot \text{K}^{-1} \cdot \text{mol}^{-1}$	
	R	$0.08206 \text{ atm} \cdot \text{L} \cdot \text{K}^{-1} \cdot \text{mol}^{-1}$	
	R	$8.31451 \text{ m}^3 \text{Pa} \cdot \text{K}^{-1} \cdot \text{mol}^{-1}$	
	R	$0.0831451 \text{ bar L} \cdot \text{K}^{-1} \cdot \text{mol}^{-1}$	
Planck's constant	h	$6.62608 \times 10^{-34} \text{ J} \cdot \text{s}$	
Speed of Light	c	$2.99792458 \times 10^8 \text{ m} \cdot \text{s}^{-1}$	

Table of Ionization Constants

Acid		$K_a =$
Iodic acid	$\text{HIO}_3 + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{IO}_3^-$	1.6×10^{-1}
Chlorous acid	$\text{HClO}_2 + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{ClO}_2^-$	1.1×10^{-2}
Chloroacetic acid	$\text{HC}_2\text{H}_2\text{ClO}_2 + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{C}_2\text{H}_2\text{ClO}_2^-$	1.4×10^{-3}
Nitrous acid	$\text{HNO}_2 + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{NO}_2^-$	7.2×10^{-4}
Hydrofluoric acid	$\text{HF} + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{F}^-$	6.6×10^{-4}
Formic acid	$\text{HCHO}_2 + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{CHO}_2^-$	1.8×10^{-4}
Benzoic acid	$\text{HC}_7\text{H}_5\text{O}_2 + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{C}_7\text{H}_5\text{O}_2^-$	6.3×10^{-5}
Hydrazoic acid	$\text{HN}_3 + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{N}_3^-$	1.9×10^{-5}
Acetic acid	$\text{HC}_2\text{H}_3\text{O}_2 + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{C}_2\text{H}_3\text{O}_2^-$	1.8×10^{-5}
Hypochlorous acid	$\text{HOCl} + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{OCl}^-$	2.9×10^{-8}
Hydrocyanic acid	$\text{HCN} + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{CN}^-$	6.2×10^{-10}
Phenol	$\text{HOC}_6\text{H}_5 + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{C}_6\text{H}_5\text{O}^-$	1.0×10^{-10}
Hydrogen peroxide	$\text{H}_2\text{O}_2 + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{HO}_2^-$	1.8×10^{-12}

Table of Solubility Product Constants

Compound	K_{sp}	Compound	K_{sp}
Mg(OH) ₂	1.2×10^{-11}	PbI ₂	7.1×10^{-9}
AgCl	1.8×10^{-10}	PbCl ₂	1.9×10^{-5}
CaSO ₄	9.1×10^{-6}	Ag ₂ CO ₃	8.5×10^{-12}
AgI	1.5×10^{-16}	ZnS	2.0×10^{-25}
BaF ₂	1.0×10^{-6}	FePO ₄	1.3×10^{-22}

