

CHEM 1515.002  
Exam III  
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April 8, 1998

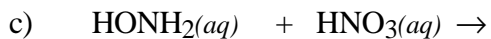
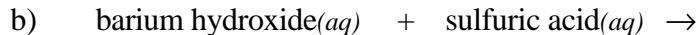
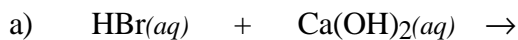
Name \_\_\_\_\_  
TA's Name \_\_\_\_\_  
Lab Section \_\_\_\_\_

### INSTRUCTIONS:

1. This examination consists of a total of 8 different pages. The last three pages include a periodic table, a solubility table, and table of weak and base equilibrium constants. All work should be done in this booklet.
2. PRINT your name, TA's name and your lab section number now in the space at the top of this sheet. DO NOT SEPARATE THESE PAGES.
3. Answer all questions that you can and whenever called for show your work clearly. Your method of solving problems should pattern the approach used in lecture. You do not have to show your work for the multiple choice or short answer questions.
4. No credit will be awarded if your work is not shown in problems 3, 4a and 5.
5. Point values are shown next to the problem number.
6. Budget your time for each of the questions. Some problems may have a low point value yet be very challenging. If you do not recognize the solution to a question quickly, skip it, and return to the question after completing the easier problems.
7. Look through the exam before beginning; plan your work; then begin.
8. ~~Relax~~ and do well.

	Page 2	Page 3	Page 4	Page 5	TOTAL
SCORES	<u>(24)</u>	<u>(26)</u>	<u>(36)</u>	<u>(14)</u>	<u>(100)</u>

(12) 1. Write the chemical formula(s) of the product(s) and balance the following reactions. Identify all products phases as either (g)as, (l)iquid, (s)olid or (aq)ueous. Soluble ionic compounds should be written in the form of their component ions.



(6) 2. Write the ionic and net ionic chemical equations for 1a) and 1b).

1a)

Ionic equation:

Net Ionic equation:

1c)

Ionic equation:

Net Ionic equation:

(6) 3a. Calculate the magnitude of the equilibrium constant for the reaction in 1a) above.

b) Calculate the magnitude of the equilibrium constant in 1c)

- (26) 4. The careful determination of the pH of a 0.01000 M solution of trichloroacetic acid,  $\text{CCl}_3\text{COOH}$ , yielded a value of 2.003.
- (8) a) calculate the  $K_a$  for trichloroacetic acid.
- (3) b) what is the conjugate base of trichloroacetic acid?
- (3) c) calculate  $K_b$  for the conjugate base.
- (6) d) would a solution of the conjugate base of trichloroacetic acid have a pH greater than, less than or approximately equal to 7? Explain.
- (6) e) Identify the chemical specie(s) in an aqueous solution of trichloroacetic acid. (NOTE: you need not include water, just the specie(s) associated with trichloroacetic acid.) Which is/are present in the highest concentration? Explain.

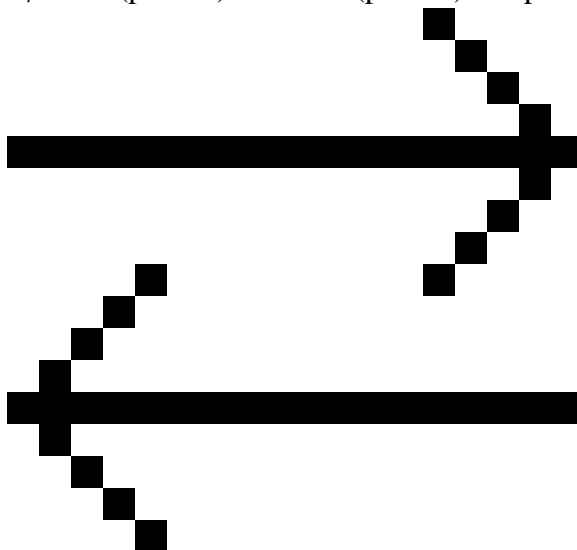
(36) 5. Calculate the pH for each of the following;

a) Calculate the pH of a 0.750 M  $\text{HC}_4\text{H}_7\text{O}_2$  solution.

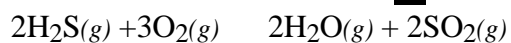
b) Calculate the pH of a 0.400 M  $\text{NaC}_6\text{H}_5\text{O}$  solution.

c) Calculate the pH of a solution prepared by mixing 25.0 mLs of 0.435 M  $\text{C}_6\text{H}_5\text{NH}_2$  and 18.0 mLs of 0.515 M  $\text{HCl}$ .

(6) 6. Is the pH of an aqueous solution of  $\text{NaH}_2\text{C}_6\text{H}_5\text{O}_7$  basic ( $\text{pH} > 7$ ) or acidic ( $\text{pH} < 7$ ). Explain.



(8) 7. The reaction



has a  $\Delta H = -1036 \text{ kJ}$ . Given the reaction is at equilibrium, predict the direction ( $\text{L} \rightarrow \text{R}$ ,  $\text{R} \rightarrow \text{L}$ , or no change) the reaction will shift when disrupted by each of the following;

- i) the amount of  $\text{H}_2\text{O}$  is increased
- ii) the temperature of the reaction is increased
- iii) the volume of the container is decreased
- iv) the amount of  $\text{H}_2\text{S}$  is decreased

**Periodic Table of the Elements**

	IA																VIII A	
1	1 <b>H</b> 1.008																	2 <b>He</b> 4.00
		IIA										IIIA	IVA	VA	VIA	VIIA		
2	3 <b>Li</b> 6.94	4 <b>Be</b> 9.01										5 <b>B</b> 10.81	6 <b>C</b> 12.01	7 <b>N</b> 14.01	8 <b>O</b> 16.00	9 <b>F</b> 19.00	10 <b>Ne</b> 20.18	
3	11 <b>Na</b> 22.99	12 <b>Mg</b> 24.30										13 <b>Al</b> 26.98	14 <b>Si</b> 28.09	15 <b>P</b> 30.97	16 <b>S</b> 32.06	17 <b>Cl</b> 35.45	18 <b>Ar</b> 39.95	
			IIIB	IVB	VB	VIB	VIIB	VIII			IB	IIB						
4	19 <b>K</b> 39.10	20 <b>Ca</b> 40.08	21 <b>Sc</b> 44.96	22 <b>Ti</b> 47.88	23 <b>V</b> 50.94	24 <b>Cr</b> 52.00	25 <b>Mn</b> 54.94	26 <b>Fe</b> 55.85	27 <b>Co</b> 58.93	28 <b>Ni</b> 58.69	29 <b>Cu</b> 63.55	30 <b>Zn</b> 65.38	31 <b>Ga</b> 69.72	32 <b>Ge</b> 72.59	33 <b>As</b> 74.92	34 <b>Se</b> 78.96	35 <b>Br</b> 79.90	36 <b>Kr</b> 83.80
5	37 <b>Rb</b> 85.47	38 <b>Sr</b> 87.62	39 <b>Y</b> 88.91	40 <b>Zr</b> 91.22	41 <b>Nb</b> 92.91	42 <b>Mo</b> 95.94	43 <b>Tc</b> (98)	44 <b>Ru</b> 101.1	45 <b>Rh</b> 102.9	46 <b>Pd</b> 106.4	47 <b>Ag</b> 107.9	48 <b>Cd</b> 112.4	49 <b>In</b> 114.8	50 <b>Sn</b> 118.7	51 <b>Sb</b> 121.8	52 <b>Te</b> 127.6	53 <b>I</b> 126.9	54 <b>Xe</b> 131.3
6	55 <b>Cs</b> 132.9	56 <b>Ba</b> 137.3	57 <b>La</b> 138.9	72 <b>Hf</b> 178.5	73 <b>Ta</b> 180.9	74 <b>W</b> 183.8	75 <b>Re</b> 186.2	76 <b>Os</b> 190.2	77 <b>Ir</b> 192.2	78 <b>Pt</b> 195.1	79 <b>Au</b> 197.0	80 <b>Hg</b> 200.6	81 <b>Tl</b> 204.4	82 <b>Pb</b> 207.2	83 <b>Bi</b> 209.0	84 <b>Po</b> (209)	85 <b>At</b> (210)	86 <b>Rn</b> (222)
7	87 <b>Fr</b> (223)	88 <b>Ra</b> 226.0	89 <b>Ac</b> 227.0	104 <b>Rf</b> (261)	105 <b>Db</b> (262)	106 <b>Sg</b> (263)	107 <b>Bh</b> (262)	108 <b>Hs</b> (265)	109 <b>Mt</b> (266)									

Lanthanides	58 <b>Ce</b> 140.1	59 <b>Pr</b> 140.9	60 <b>Nd</b> 144.2	61 <b>Pm</b> (145)	62 <b>Sm</b> 150.4	63 <b>Eu</b> 152.0	64 <b>Gd</b> 157.2	65 <b>Tb</b> 158.9	66 <b>Dy</b> 162.5	67 <b>Ho</b> 164.9	68 <b>Er</b> 167.3	69 <b>Tm</b> 168.9	70 <b>Yb</b> 173.0	71 <b>Lu</b> 175.0
Actinides	90 <b>Th</b> 232.0	91 <b>Pa</b> 231.0	92 <b>U</b> 238.0	93 <b>Np</b> 237.0	94 <b>Pu</b> (244)	95 <b>Am</b> (243)	96 <b>Cm</b> (247)	97 <b>Bk</b> (247)	98 <b>Cf</b> (251)	99 <b>Es</b> (252)	100 <b>Fm</b> (257)	101 <b>Md</b> (258)	102 <b>No</b> (259)	103 <b>Lr</b> (260)

## Useful Information

## Equations

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

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

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

$$x_{1,2} = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \quad \text{for } ax^2 + bx + c = 0$$

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

## Constants

$$K_w = 1.0 \times 10^{-14}$$

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

## Solubility Table

<u>Ion</u>	<u>Solubility</u>	<u>Exceptions</u>
NO <sub>3</sub> <sup>-</sup>	soluble	none
ClO <sub>4</sub> <sup>-</sup>	soluble	none
Cl <sup>-</sup>	soluble	except Ag <sup>+</sup> , Hg <sub>2</sub> <sup>2+</sup> , *Pb <sup>2+</sup>
I <sup>-</sup>	soluble	except Ag <sup>+</sup> , Hg <sub>2</sub> <sup>2+</sup> , Pb <sup>2+</sup>
SO <sub>4</sub> <sup>2-</sup>	soluble	except Ca <sup>2+</sup> , Ba <sup>2+</sup> , Sr <sup>2+</sup> , Hg <sup>2+</sup> , Pb <sup>2+</sup> , Ag <sup>+</sup>
CO <sub>3</sub> <sup>2-</sup>	insoluble	except Group IA and NH <sub>4</sub> <sup>+</sup>
PO <sub>4</sub> <sup>3-</sup>	insoluble	except Group IA and NH <sub>4</sub> <sup>+</sup>
-OH	insoluble	except Group IA, *Ca <sup>2+</sup> , Ba <sup>2+</sup> , Sr <sup>2+</sup>
S <sup>2-</sup>	insoluble	except Group IA, IIA and NH <sub>4</sub> <sup>+</sup>
Na <sup>+</sup>	soluble	none
NH <sub>4</sub> <sup>+</sup>	soluble	none
K <sup>+</sup>	soluble	none

\*slightly soluble

Metal	Half-Reaction Reaction
Lithium	Li → Li <sup>+</sup> + e <sup>-</sup>
Potassium	K → K <sup>+</sup> + e <sup>-</sup>
Barium	Ba → Ba <sup>2+</sup> + 2e <sup>-</sup>
Calcium	Ca → Ca <sup>2+</sup> + 2e <sup>-</sup>
Sodium	Na → Na <sup>+</sup> + e <sup>-</sup>
Magnesium	Mg → Mg <sup>2+</sup> + 2e <sup>-</sup>
Aluminum	Al → Al <sup>3+</sup> + 3e <sup>-</sup>
Manganese	Mn → Mn <sup>2+</sup> + 2e <sup>-</sup>
Zinc	Zn → Zn <sup>2+</sup> + 2e <sup>-</sup>
Chromium	Cr → Cr <sup>3+</sup> + 3e <sup>-</sup>
Iron	Fe → Fe <sup>2+</sup> + 2e <sup>-</sup>
Cobalt	Co → Co <sup>2+</sup> + 2e <sup>-</sup>
Nickel	Ni → Ni <sup>2+</sup> + 2e <sup>-</sup>
Tin	Sn → Sn <sup>2+</sup> + 2e <sup>-</sup>
Lead	Pb → Pb <sup>2+</sup> + 2e <sup>-</sup>
Hydrogen	H <sub>2</sub> → 2H <sup>+</sup> + 2e <sup>-</sup>
Copper	Cu → Cu <sup>2+</sup> + 2e <sup>-</sup>
Silver	Ag → Ag <sup>+</sup> + e <sup>-</sup>
Mercury	Hg → Hg <sup>2+</sup> + 2e <sup>-</sup>
Platinum	Pt → Pt <sup>2+</sup> + 2e <sup>-</sup>
Gold	Au → Au <sup>3+</sup> + 3e <sup>-</sup>

## E.1 DISSOCIATION CONSTANTS FOR ACIDS AT 25 °C

Name	Formula	$K_{a1}$	$K_{a2}$	$K_{a3}$
Acetic	$\text{HC}_2\text{H}_3\text{O}_2$	$1.8 \times 10^{-5}$		
Ascorbic	$\text{HC}_6\text{H}_7\text{O}_6$	$8.0 \times 10^{-3}$		
Arsenic	$\text{H}_3\text{AsO}_4$	$5.6 \times 10^{-3}$	$1.0 \times 10^{-7}$	$3.0 \times 10^{-12}$
Arsenous	$\text{H}_3\text{AsO}_3$	$6.0 \times 10^{-10}$		
Benzoic	$\text{HC}_7\text{H}_5\text{O}_2$	$6.5 \times 10^{-5}$		
Boric	$\text{H}_3\text{BO}_3$	$5.8 \times 10^{-10}$		
Butyric acid	$\text{HC}_4\text{H}_7\text{O}_2$	$1.5 \times 10^{-5}$		
Carbonic	$\text{H}_2\text{CO}_3$	$4.3 \times 10^{-7}$	$5.6 \times 10^{-11}$	
Cyanic	$\text{HCNO}$	$3.5 \times 10^{-4}$		
Citric	$\text{H}_3\text{C}_6\text{H}_5\text{O}_7$	$7.4 \times 10^{-4}$	$1.7 \times 10^{-5}$	$4.0 \times 10^{-7}$
Formic	$\text{HCHO}_2$	$1.8 \times 10^{-4}$		
Hydroazoic	$\text{HN}_3$	$1.9 \times 10^{-5}$		
Hydrocyanic	$\text{HCN}$	$4.9 \times 10^{-10}$		
Hydrofluoric	$\text{HF}$	$7.2 \times 10^{-4}$		
Hydrogen chromate ion	$\text{HCrO}_4^-$	$3.0 \times 10^{-7}$		
Hydrogen peroxide	$\text{H}_2\text{O}_2$	$2.4 \times 10^{-12}$		
Hydrogen selenate ion	$\text{HSeO}_4^-$	$2.2 \times 10^{-2}$		
Hydrogen sulfate ion	$\text{HSO}_4^-$	$1.2 \times 10^{-2}$		
Hydrogen sulfide	$\text{H}_2\text{S}$	$5.7 \times 10^{-8}$	$1.3 \times 10^{-13}$	
Hypobromous	$\text{HBrO}$	$2.0 \times 10^{-9}$		
Hypochlorous	$\text{HClO}$	$3.0 \times 10^{-8}$		
Hypoiodous	$\text{HIO}$	$2.0 \times 10^{-11}$		
Iodic	$\text{HIO}_3$	$1.7 \times 10^{-1}$		
Lactic	$\text{HC}_3\text{H}_5\text{O}_3$	$1.4 \times 10^{-4}$		
Malonic	$\text{H}_2\text{C}_3\text{H}_2\text{O}_4$	$1.5 \times 10^{-3}$	$2.0 \times 10^{-6}$	
Oxalic	$\text{H}_2\text{C}_2\text{O}_4$	$5.9 \times 10^{-2}$	$6.4 \times 10^{-5}$	
Nitrous	$\text{HNO}_2$	$4.5 \times 10^{-4}$		
Phenol	$\text{HC}_6\text{H}_5\text{O}$	$1.3 \times 10^{-10}$		
Phosphoric	$\text{H}_3\text{PO}_4$	$7.5 \times 10^{-3}$	$6.2 \times 10^{-8}$	$4.2 \times 10^{-13}$
Paraperiodic	$\text{H}_5\text{IO}_6$	$2.8 \times 10^{-2}$	$5.3 \times 10^{-9}$	
Propanoic	$\text{HC}_3\text{H}_5\text{O}_2$	$1.4 \times 10^{-5}$		
Pyrophosphoric	$\text{H}_4\text{P}_2\text{O}_7$	$3.0 \times 10^{-2}$	$4.4 \times 10^{-3}$	
Selenous	$\text{H}_2\text{SeO}_3$	$2.3 \times 10^{-3}$	$5.3 \times 10^{-9}$	
Sulfuric	$\text{H}_2\text{SO}_4$	strong acid	$1.2 \times 10^{-2}$	
Tartaric	$\text{H}_2\text{C}_4\text{H}_4\text{O}_6$	$1.0 \times 10^{-3}$	$4.6 \times 10^{-5}$	

## E.2 DISSOCIATION CONSTANTS FOR BASES AT 25°C

Name	Formula	$K_b$	Name	Formula	$K_b$
Ammonia	$\text{NH}_3$	$1.8 \times 10^{-5}$	Hydrazine	$\text{H}_2\text{NNH}_2$	$1.3 \times 10^{-6}$
Aniline	$\text{C}_6\text{H}_5\text{NH}_2$	$4.3 \times 10^{-10}$	Methylamine	$\text{CH}_3\text{NH}_2$	$4.4 \times 10^{-4}$
Dimethylamine	$(\text{CH}_3)_2\text{NH}$	$5.4 \times 10^{-4}$	Pyridine	$\text{C}_5\text{H}_5\text{N}$	$1.7 \times 10^{-9}$
Ethylamine	$\text{C}_2\text{H}_5\text{NH}_2$	$6.4 \times 10^{-4}$	Trimethylamine	$(\text{CH}_3)_3\text{N}$	$6.4 \times 10^{-5}$
Hydroxylamine	$\text{HONH}_2$	$1.1 \times 10^{-8}$			