CHEM 1515
Exam III
John III. Gelder
April 7, 1993

Name ____________________
TA's Name ____________________
Lab Section ____________________

INSTRUCTIONS:

1. This examination consists of a total of 8 different pages. The last 2 pages include important mathematical equations and constants, a solubility table, a periodic table, and a table of dissociation constants. All work should be done in this booklet. You may *carefully* remove the last 2 pages of the examination.

2. PRINT your name, your TA's name and your laboratory section now in the space at the top of this sheet. DO NOT SEPARATE THE 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 2 – 4. Please circle your final answer!

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	____ (29)	____ (30)	____ (20)	____ (21)	____ (100)

(9) 1. Complete and balance the following reactions. Identify all product's phases as either (g)as, (l)iquid, (s)olid or (aq)ueous. Products which are soluble ionic compounds must be written as ions. If no reaction occurs, write NR.

a) $KHC_8H_4O_4$*(aq)* + KOH*(aq)* $\rightarrow$

b) $Cu(NO_3)_2$*(aq)* + KIO_3*(aq)* $\rightarrow$

c) C_5H_5N*(aq)* + $HC_2H_3O_2$*(aq)* $\rightarrow$

(10) 2. Calculate the pH of an aqueous solution which is 0.832 M $(CH_3)_3N$.

(10) 3. Calculate the pH of an aqueous solution formed after mixing 40.0 mL of 0.160 M KOH and 30.0 mL of 0.300 M $HC_4H_7O_2$.

(30) 4a. Calculate the pH of 500. mL of an aqueous solution which is 0.0250 M $HC_7H_5O_2$ (benzoic acid).

b. Calculate the pH of the 500. mL solution in part a) after adding 0.0100 moles of $KC_7H_5O_2$. (Assume no volume change.)

c. Briefly explain why the pH of the solution in part b) differs from the pH of the solution in part a).

d. Calculate the pH of the 500. mL solution in part b) after adding 0.00750 moles of HNO_3. (Assume no volume change.)

(20) 5. The formula for acetic acid, $HC_2H_3O_2$, which we use in class can also be written as CH_3COOH.

a) draw the Lewis structure for acetic acid.

b) write the chemical equation which describes how acetic acid acts as an acid.

c) write the definition of a Brø nsted-Lowry acid

d) using the Lewis structure in part a) identify the acidic hydrogen in acetic acid.

e) write the formula for, and draw the Lewis structure for the conjugate base of acetic acid

f) write the definiton for a Brø nsted-Lowry base.

g) trichloroacetic acid has the formula $HC_2Cl_3O_2$. Draw a Lewis structure for trichloroacetic acid. Would you predict trichloroacetic acid to be a stronger acid compared to acetic acid, weaker or about the same in strength? Provide a brief explanation to support your answer.

Multiple Choice: (14 points)

Print the letter (A, B, C, D, E) which corresponds to the answer selected.

6. ________ 7. ________ 8. ________ 9. ________

10. ________ 11. ________ 12. ________

ONLY THE ANSWERS IN THE AREA ABOVE WILL BE GRADED. Select the most correct answer for each question. Each question is worth 3 points.

6. Which of the following buffer systems would be the best to use if you needed to prepare a buffer with nearly equal amounts of the acid and conjugate base and having a pH = 7.40, the same pH as blood?
A) $H_3PO_4/H_2PO_4^-$
B) $HC_2H_3O_2/C_2H_3O_2^-$
C) $H_2PO_4^-/HPO_4^{2-}$
D) NH_4^+/NH_3
E) H_2CO_3/HCO_3^-

7. Which of the following is the strongest base?
A) 0.100 M $C_6H_5NH_2$
B) 0.100 M KCN
C) 0.100 M HSO_4^-
D) 0.100 M NH_3
E) 0.100 M $C_2H_5NH_3^+$

8. Calculate the magnitude of the equilibrium constant for the following reaction

$$HCN(aq) + C_2H_5NH_2(aq) \rightarrow C_2H_5NH_3^+(aq + CN^-(aq)$$

A) 1.0×10^{14}
B) 6.4×10^{10}
C) 4.9×10^{4}
D) 3.14×10^{1}

9. Which of the following salts gives an acidic solution?

A) $CH_3NH_3ClO_4$
B) NaCl
C) K_2CO_3
D) $KC_2H_3O_2$
E) CaS

10. Calculate the initial concentration of a sample of acetic acid if the pH of the solution is 4.85.

A) 4.85 M
B) 0.100 M
C) 1.1×10^{-5} M
D) 1.4×10^{-5} M
E) 2.5×10^{-5} M

11. A solution is labeled “0.100 M H_2CO_3,”

A) $[H^+]$ less than 0.100 M
B) $[CO_3^{2-}]$ = 0.100 M
C) $[H^+]$ = 0.100 M
D) $[HCO_3^-]$ = 0.0500 M
E) $[H^+]$ = 0.200 M

12. The pH of a 3.50×10^{-3} M $Ca(OH)_2$ solution is,

A) 2.15
B) 2.46
C) 11.54
D) 11.85
E) can not determine the pH of the solution without a value for K_b.

Useful Information

Equations

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

$pH + pOH = 14$

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

Constants

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

Solubility Table

Ion	Solubility	Exceptions
NO_3^-	soluble	none
ClO_4^-	soluble	except NH_4^+
Cl^-	soluble	except Ag^+, Hg_2^{2+}, *Pb^{2+}
SO_4^{2-}	soluble	except Ca^{2+}, Ba^{2+}, Sr^{2+}, Hg^{2+}, Pb^{2+}, Ag^+
CO_3^{2-}	insoluble	except Group IA and NH_4^+
PO_4^{3-}	insoluble	except Group IA and NH_4^+
^-OH	insoluble	except Group IA, *Ca^{2+}, Ba^{2+}, Sr^{2+}
S^{2-}	insoluble	except Group IA, IIA and NH_4^+
Na^+	soluble	none
NH_4^+	soluble	except ClO_4^-
K^+	soluble	none

*slightly soluble

Periodic Table of the Elements

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

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

E.1 DISSOCIATION CONSTANTS FOR ACIDS AT 25 ˚C

Name	Formula	K_{a1}	K_{a2}	K_{a3}
Acetic	$HC_2H_3O_2$	1.8×10^{-5}		
Ascorbic	$HC_6H_7O_6$	8.0×10^{-3}		
Arsenic	H_3AsO_4	5.6×10^{-3}	1.0×10^{-7}	3.0×10^{-12}
Arsenous	H_3AsO_3	6.0×10^{-10}		
Benzoic	$HC_7H_5O_2$	6.5×10^{-5}		
Boric	H_3BO_3	5.8×10^{-10}		
Butyric acid	$HC_4H_7O_2$	1.5×10^{-5}		
Carbonic	H_2CO_3	4.3×10^{-7}	5.6×10^{-11}	
Cyanic	$HCNO$	3.5×10^{-4}		
Citric	$H_3C_6H_5O_7$	7.4×10^{-4}	1.7×10^{-5}	4.0×10^{-7}
Formic	$HCHO_2$	1.8×10^{-4}		
Hydroazoic	HN_3	1.9×10^{-5}		
Hydrocyanic	HCN	4.9×10^{-10}		
Hydrofluoric	HF	7.2×10^{-4}		
Hydrogen chromate ion	$HCrO_4^-$	3.0×10^{-7}		
Hydrogen peroxide	H_2O_2	2.4×10^{-12}		
Hydrogen selenate ion	$HSeO_4^-$	2.2×10^{-2}		
Hydrogen sulfate ion	HSO_4^-	1.2×10^{-2}		
Hydrogen sulfide	H_2S	5.7×10^{-8}	1.3×10^{-13}	
Hypobromous	$HBrO$	2.0×10^{-9}		
Hypochlorous	$HClO$	3.0×10^{-8}		
Hypoiodus	HIO	2.0×10^{-11}		
Iodic	HIO_3	1.7×10^{-1}		
Lactic	$HC_3H_5O_3$	1.4×10^{-4}		
Malonic	$H_2C_3H_2O_4$	1.5×10^{-3}	2.0×10^{-6}	
Oxalic	$H_2C_2O_4$	5.9×10^{-2}	6.4×10^{-5}	
Nitrous	HNO_2	4.5×10^{-4}		
Phenol	HC_6H_5O	1.3×10^{-10}		
Phosphoric	H_3PO_4	7.5×10^{-3}	6.2×10^{-8}	4.2×10^{-13}
Paraperiodic	H_5IO_6	2.8×10^{-2}	5.3×10^{-9}	
Propanoic	$HC_3H_5O_2$	1.4×10^{-5}		
Pyrophosphoric	H_4P_2O	3.0×10^{-2}	4.4×10^{-3}	
Selenous	H_2SeO_3	2.3×10^{-3}	5.3×10^{-9}	
Sulfuric	H_2SO_4	strong acid	1.2×10^{-2}	
Sulfurous	H_2SO_3	1.7×10^{-2}	6.4×10^{-8}	
Tartaric	$H_2C_4H_4O_6$	1.0×10^{-3}	4.6×10^{-5}	

E.2 DISSOCIATION CONSTANTS FOR BASES AT 25˚C

Name	Formula	K_b	Name	Formula	K_b
Ammonia	NH_3	1.8×10^{-5}	Hydroxylamine	$HONH_2$	1.1×10^{-8}
Aniline	$C_6H_5NH_2$	4.3×10^{-10}	Methylamine	CH_3NH_2	4.4×10^{-4}
Dimethylamine	$(CH_3)_2NH$	5.4×10^{-4}	Pyridine	C_5H_5N	1.7×10^{-9}
Ethylamine	$C_2H_5NH_2$	6.4×10^{-4}	Trimethylamine	$(CH_3)_3N$	6.4×10^{-5}
Hydrazine	H_2NNH_2	1.3×10^{-6}			