CHEM 1515.001 - 006
Exam III
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Name _____

TA's Name _____

Section _____

INSTRUCTIONS:

1. This examination consists of a total of 8 different pages. The last three pages include a periodic table, a table of equilbrium constants, a solubility table and some useful equations. 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 3, 5 and 6.

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	_____	_____	_____	_____	_____
	(26)	(16)	(36)	(22)	(100)

(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.

a) $H_2SO_{4(aq)} + Mg_{(s)} \rightarrow \mathbf{Mg^{2+}_{(aq)} + SO_4^{2-}{}_{(aq)} + H_{2(aq)}}$

b) $Mg(NO_3)_{2(aq)} + \mathbf{2}NaOH_{(aq)} \rightarrow \mathbf{Mg(OH)_{2(s)} + 2Na^{+}_{(aq)} + 2OH^{-}_{(aq)}}$

c) $KOH_{(aq)} + HI_{(aq)} \rightarrow \mathbf{H_2O_{(l)} + K^{+}_{(aq)} + I^{-}_{(aq)}}$

d) $NH_{3(aq)} + HC_2H_3O_{2(aq)} \rightarrow \mathbf{NH_4^{+}{}_{(aq)} + C_2H_3O_2^{-}{}_{(aq)}}$

(4) 2a. Write the ionic and net ionic chemical equation for 1a), 1b), 1c) or 1d).

Ionic equation

Net Ionic equation

(10) 3. At high temperature HCl and O_2 react to give Cl_2 gas:

$$4HCl_{(g)} + O_{2(g)} \rightleftarrows 2Cl_{2(g)} + 2H_2O_{(g)}$$

2.30 atm of HCl and 1.00 atm of O_2 are introduced into a container at 750 K. After equilibrium is established the partial pressure of Cl_2 is found to be 0.93 atm. Calculate K_p for the reaction.

P_{HCl} = 0.44 atm P_{Cl_2} = 0.93 atm P_{O_2} = 0.53 atm P_{H_2O} = 0.93 atm

K_P = 37.7

(12) 4. The following exothermic reaction is at equilibrium

$$2SO_{2(g)} + O_{2(g)} \rightleftarrows 2SO_{3(g)}$$

Predict what happens to the amount of SO_3 when each of the following changes is made. Provide a brief explanation for your prediction.

a) The temperature is raised.

[SO_3] decreases..rxn exothermic, so raising the temperature is equivalent to adding heat to the products side of the reaction, the reaction will proceed from R to L to reduce the amount of heat added.

b) More O_2 is added.

[SO_3] increases..adding will mean Q will be less than K. To re-establish equilibrium the products must increase and the reactants decrease so the reaction proceeds L to R.

c) The volume of the container is increased.

[SO_3] decrease..increasing the volume will cause Q will be greater than K. To re-establish equilibrium the products must decrease and the reactants increase so the reaction proceeds R to L.

(4) 5. K_c for the reaction

$$2N_2O(g) + O_2(g) \rightleftarrows 4NO(g)$$

is 3.39×10^{-8} at 1000 K. Calculate K'_c for the reaction

$$NO(g) \rightleftarrows \frac{1}{2}N_2O(g) + \frac{1}{4}O_2(g)$$

$$\mathbf{K = \frac{1}{K_c^{1/4}} \frac{1}{(3.39 \times 10^{-8})^{1/4}}\ 73.7}$$

(36) 6. Calculate the pH for each of the following solutions.

a) 0.450 M HCN

pH = 4.82

b) 0.210 M C_5H_5N

pH = 9.27

c) 0.840 M $C_6H_5NH_3NO_3$

pH = 2.35

(22)7a. Write a chemical equation to describe how each of the following behave as acids when dissolved in water. (4)

i) $HCHO_2 \rightleftarrows$ **H^+*(aq)* + CHO_2^-*(aq)***

ii) $HF \rightleftarrows$ **H^+*(aq)* + F^-*(aq)***

a) Given solutions of the same concentration which acid in part a) is the strongest? Support your answer with a short explanation. (4)

K(HF) = 7.2 x 10^{-4}

K($HCHO_2$) = 1.8 x 10^{-4}

K is larger for HF so it is the stronger acid.

b) Given solutions of the same concentration which base F^- or CHO_2^- is the strongest? Support your answer with a short explanation. (4)

c) Write a neutralization reaction between the strongest acid from part b) and the strongest base in part c). (4)

HF*(aq)* + CHO_2^-*(aq)* $\rightleftarrows$ $HCHO_2$*(aq)* + F^-*(aq)*

d) Does Na_2HPO_4 behave as an acid or base when added to water? Explain. (6)

Periodic Table of the Elements

	IA	IIA	IIIB	IVB	VB	VIB	VIIB	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)

Useful Information

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

$pH + pOH = 14$

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

$K_w = 1.00 \times 10^{-14}$

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

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

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

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}	
Propionic	$HC_3H_5O_2$	1.3×10^{-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}			

Solubility Table

Ion	Solubility	Exceptions
NO_3^-	soluble	none
ClO_4^-	soluble	none
Cl^-	soluble	except Ag^+, Hg_2^{2+}, *Pb^{2+}
I^-	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	none
K^+	soluble	none

*slightly soluble