CHEM 1225
Exam III
John III. Gelder
April 8, 1999

Name _____

TA's Name _____

Lab Section _____

INSTRUCTIONS:

1. This examination consists of a total of 7 different pages. The last two pages includes a periodic table and a solubility table. 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 (if any) or short answer questions.

4. No credit will be awarded if your work is not shown in problems 3 – 5, 7, 8, 10 and 11.

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	Page 6	TOTAL
SCORES	_____	_____	_____	_____	_____	_____
	(20)	(22)	(22)	(18)	(18)	(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.

a) $K_2CrO_{4(aq)} + Pb(NO_3)_{2(aq} \rightarrow \mathbf{PbCrO_{4(s)} + 2KNO_{3(aq)}}$

b) $H_2SO_{4(aq)} + 2KOH_{(aq)} \rightarrow \mathbf{K_2SO_{4(aq)} + 2H_2O_{(aq)}}$

c) $NaOH_{(aq)} + HC_2H_3O_{2(aq)} \rightarrow \mathbf{NaC_2H_3O_{2(aq)} + H_2O_{(aq)}}$

d) $CaCO_{3(s)} + HCl_{(aq)} \rightarrow \mathbf{CaCl_{2(aq)} + CO_{2(aq)} + H_2O_{(aq)}}$

(8) 2. Write the balanced ionic and balanced net ionic chemical equations for any two of the reactions in Problem 1. (Remember to include the correct charges on all ions and the phase of each species.)

1a, 1b, 1c or 1d)

Ionic equation:

$$\mathbf{2K^+(aq) + CrO_4^{2-}(aq) + 2NO_3^-(aq) + Pb^{2+}(aq) \rightarrow PbCrO_{4(s)} + 2K^+(aq) + 2NO_3^-(aq)}$$

Net Ionic equation:

$$\mathbf{CrO_4^{2-}(aq) + Pb^{2+}(aq) \rightarrow PbCrO_{4(s)}}$$

1a, 1b or 1c)

Ionic equation:

$$\mathbf{2H^+(aq) + SO_4^{2-}(aq) + 2OH^-(aq) + K^+(aq) \rightarrow 2K^+(aq) + SO_4^{2-}(aq) + 2H_2O_{(aq)}}$$

Net Ionic equation:

$$\mathbf{H^+(aq) + OH^-(aq) \rightarrow H_2O_{(aq)}}$$

1a, 1b or 1c)

Ionic equation:

$$\mathbf{H^+(aq) + C_2H_3O_2^-(aq) + OH^-(aq) + Na^+(aq) \rightarrow Na^+(aq) + C_2H_3O_2^-(aq) + H_2O_{(aq)}}$$

Or more correct

$$\mathbf{HC_2H_3O_2^-(aq) + OH^-(aq) + Na^+(aq) \rightarrow Na^+(aq) + C_2H_3O_2^-(aq) + H_2O_{(aq)}}$$

Net Ionic equation:

$$\mathbf{H^+(aq) + OH^-(aq) \rightarrow H_2O_{(aq)}}$$

Or more correct

$$\mathbf{HC_2H_3O_2^-(aq) + OH^-(aq) \rightarrow C_2H_3O_2^-(aq) + H_2O_{(aq)}}$$

(12) 3. Describe how you would prepare;

a) 500.00 mls of a 1.25 M Na_2SO_4 solution.

$$\mathbf{0.500\ L\left(\frac{1.25\ mol}{1\ Liter}\right) = 0.625\ mol\ Na_2SO_4}$$

$$\mathbf{0.625\ mol\left(\frac{142\ g}{1\ mol}\right) = 88.8\ gm\ Na_2SO_4}$$

Wearing your safety goggles, add the Na_2SO_4 solid to approximately 300 mL of water and be sure the solid has completely dissolved. Then add enough water to obtain 500.0 mL solution. (Note: we do not have to worry about how much water is added, only the final volume.)

b) 1 liter of 0.733 M $KMnO_4$ from a solution which is 1.39 M $KMnO_4$.

$$\mathbf{M_1V_1 = M_2V_2}$$

$$\mathbf{V_1 = \left(\frac{M_2V_2}{M_1}\right) = \left(\frac{0.733\ M \cdot 1\ L}{1.39\ M}\right) = 527\ mLs}$$

Add enough water to 527 mLs of 1.39 M $KMnO_4$ to get 1 L of 0.733 M solution.

(10) 4. Some sulfuric acid is spilled on a bench top in the laboratory. Sodium hydrogen carbonate is sprinkled on the spill. The balanced equation describing the reaction which takes place,

$$2NaHCO_{3(s)} + H_2SO_{4(aq)} \rightarrow Na_2SO_{4(aq)} + CO_{2(g)} + 2H_2O_{(l)}$$

Calculate the mass of sodium hydrogen carbonate that must be weighed out to react with 400. mLs of 6.00 M H_2SO_4 that was spilled.

$$\mathbf{400.0\ mLs\left(\frac{1\ L}{1000\ mL}\right)\left(\frac{6.00\ mol\ H_2SO_4}{1\ L}\right) = 2.40\ mol\ H_2SO_4}$$

$$\mathbf{2.40\ mol\ H_2SO_4\left(\frac{2\ mol\ NaHCO_3}{1\ mol\ H_2SO_4}\right)\left(\frac{84\ g\ NaHCO_3}{1\ mol\ NaHCO_3}\right) = 403\ g\ NaHCO_3}$$

(10) 5. Nitric acid reacts with barium hydroxide according to the equation;

$$2HNO_{3(aq)} + Ba(OH)_{2(aq)} \rightarrow Ba(NO_3)_{2(aq)} + 2H_2O_{(g)}$$

Calculate the volume of 0.259 M nitric acid required to exactly neutralize 18.0 mLs of 0.185 M barium hydroxide.

$$\mathbf{0.0180\ L\left(\frac{0.185\ mol\ Ba(OH)_2}{1\ L}\right)\left(\frac{2\ mol\ HNO_3}{1\ mol\ Ba(OH)_2}\right)\left(\frac{1\ L}{0.259\ mol\ HNO_3}\right) = 0.0260\ L\ HNO_3}$$

(4) 6. Write the equilibrium expression for each of the following chemical equations;

a)

$$N_{2(g)} + 3Cl_{2(g)} \rightleftarrows 2NCl_{3(g)}$$

$$\mathbf{K = \frac{[NCl_3]^2}{[N_2][Cl_2]^3}}$$

b)

$$2C_8H_{18(l)} + 17O_{2(g)} \rightleftarrows 8CO_{2(g)} + 18H_2O_{(g)}$$

$$\mathbf{K = \frac{[CO_2]^8[H_2O]^{18}}{[O_2]^{17}}}$$

(8) 7. The equation describing the industrial preparation of ammonia is;

$$N_{2(g)} + 3H_{2(g)} \rightleftarrows 2NH_{3(g)}$$

Suppose that a reaction mixture at a given temperature, at equilibrium, was analyzed and found to contain 3.45 x 10^{-4} M NH_3, 8.17 x 10^{-4} M N_2, and 0.580 M H_2. Calculate the magnitude of the equilibrium constant for the reaction.

$$\mathbf{K = \frac{[NH_3]^2}{[N_2][H_2]^3}}$$

$$\mathbf{K = \frac{[3.45 \times 10^{-4}]^2}{[8.17 \times 10^{-4}][0.580]^3}}$$

$$\mathbf{K = 7.47 \times 10^{-4}}$$

(10) 8. When 0.981 moles of NO, 0.483 moles of Cl_2 and 0.400 moles of NOCl are sealed in a 1.00 L flask at 220 ˚C, the following equilibrium is established,

$$2NO_{(g)} + Cl_{2(g)} \rightleftarrows 2NOCl_{(g)}$$

After the mixture achieves equilibrium analysis shows the concentration of NOCl to be 0.222 M. Calculate K for the reaction.

	$2NO_{(g)}$	$+ Cl_{2(g)} \rightleftarrows$	$2NOCl_{(g)}$
Initial	**0.981**	**0.483**	**0.400**
Change			
Equilibrium			**0.222**

Since 0.222 moles of NOCl are formed at equilibrium, 0.178 moles of NOCl must have reacted. So 0.178 moles is the change in NOCl. We now use stoichiometry to calculate the change of NO and Cl_2.

$$\mathbf{0.178\ mol\ NOCl}\left(\frac{\mathbf{2\ mol\ NO}}{\mathbf{2\ mol\ NOCl}}\right) = \mathbf{0.178\ mol\ NO}$$

$$\mathbf{0.178\ mol\ NOCl}\left(\frac{\mathbf{1\ mol\ Cl_2}}{\mathbf{2\ mol\ NOCl}}\right) = \mathbf{0.089\ mol\ Cl_2}$$

Remember since NOCl reacted, NO and Cl_2 are formed.
Now the ICE table looks like

	$2NO_{(g)}$	$+ Cl_{2(g)} \rightleftarrows$	$2NOCl_{(g)}$
Initial	**0.981**	**0.483**	**0.400**
Change	**+0.178**	**+0.089**	**-0.178**
Equilibrium	**1.16**	**0.661**	**0.222**

$$\mathbf{K = \frac{[NOCl]^2}{[Cl_2][NO]^2}}$$

$$\mathbf{K = \frac{[0.222]^2}{[0.661][1.16]^2}}$$

$$\mathbf{K = 0.055}$$

(8) 9. For the system

$$heat + 2N_{2(g)} + 6H_2O_{(g)} \rightleftarrows 3O_{2(g)} + 4NH_{3(g)}$$

How will the $[NH_3]$ be effected (increase, decrease or no change) when the equilibrium is disturbed by;

a) Removal of O_2 **increase**

b) Addition of H_2O **increase**

c) Increase in temperature **increase**

d) Decrease in the volume of the reaction container **increase**

(9) 10. Calculate the solubility of $PbCO_3$ in pure water. $K_{sp} = 1.0 \times 10^{-13}$

$$PbCO_{3(s)} \rightleftarrows Pb^{2+}_{(aq)} + CO_3^{2-}_{(aq)}$$

I	-	**0**	**0**	
C	-	**+x**	**+x**	**x = solubility of $PbCO_3$**
E	-	**x**	**x**	

$$\mathbf{K_{sp} = [Pb^{2+}][CO_3^{2-}]}$$
$$\mathbf{1.0 \times 10^{-13} = (x)(x)}$$
$$\mathbf{1.0 \times 10^{-13} = x^2}$$
$$\mathbf{3.16 \times 10^{-7}\ M = x = \text{solubility of } PbCO_3}$$

(9) 11. The concentration of Mg^{2+} in a saturated solution of $Mg(OH)_2$ is 1.16×10^{-4} M. Calculate the magnitude of the equilibrium constant, K_{sp}, for $Mg(OH)_2$.

$$Mg(OH)_{2(s)} \rightleftarrows Mg^{2+}_{(aq)} + 2OH^-_{(aq)}$$

I	-	**0**	**0**
C	-	**$+1.16 \times 10^{-4}$**	**$2(1.16 \times 10^{-4})$**
E	-	**1.16×10^{-4}**	**2.32×10^{-4}**

$$\mathbf{K_{sp} = [Mg^{2+}][OH^-]^2}$$
$$\mathbf{K_{sp} = [1.16 \times 10^{-4}][2.32 \times 10^{-4}]^2}$$
$$\mathbf{K_{sp} = 6.24 \times 10^{-12}}$$

Periodic Table of the Elements

	IA												IIIA	IVA	VA	VIA	VIIA	VIIIA
1	1 **H** 1.008	IIA																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	IIIB	IVB	VB	VIB	VIIB	VIII			IB	IIB	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 **Rf** (261)	105 **Db** (262)	106 **Sg** (263)	107 **Bh** (262)	108 **Hs** (265)	109 **Mt** (266)									

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)

Solubility Table

Ion	Solubility	Exceptions
NO_3^-	soluble	none
ClO_4^-	soluble	none
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^+
CrO_4^{2-}	insoluble	except Group IA, IIA 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