CHEM 1515.001 - 009
Exam III
John III. Gelder
April 2, 2003

Name _____

TA's Name _____

Section _____

INSTRUCTIONS:

1. This examination consists of a total of 10 different pages. The last three pages include a periodic table; useful mathematical equations and constants, a table of equilibrium constants; a solubility table; and an activity series. 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, 4b, and 5c.

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	_____	_____	_____	_____	_____	_____
	(23)	(20)	(22)	(23)	(12)	(100)

(9) 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) $HBr_{(aq)} + NH_{3(aq)} \rightarrow$

b) $HC_9H_7O_{4(aq)} + NaOH_{(aq)} \rightarrow$

c) $Al_{(s)} + Ni(NO_3)_{2(aq)} \rightarrow$

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

Ionic equation

Net Ionic equation

(30) 3. Calculate the pH for each of the following solutions.

a) 0.00350 M $HClO_4$

3. (CONTINUED)

b) 0.520 M $C_6H_5NH_2$ (aniline)

c) 0.250 M $HC_7H_5O_2$ (benzoic acid)

(25) 4. In petroleum refining longer chain hydrocarbons are 'cracked' into smaller hydrocarbons. One such reaction is

$$C_4H_{10(g)} \rightleftharpoons C_2H_{6(g)} + C_2H_{4(g)}$$

a) write the equilibrium constant expression for K_P for the chemical reaction. (3)

b) When 50.0 atm of butane are placed into a closed container at 500 ˚C and allowed to reached equilibrium according to the equation above, the partial pressure of ethane is found to be 19.2 atm. Calculate the equilibrium partial pressures of the remaining substances and K_P for the reaction. (8)

c) Suppose after equilibrium is attained in part b) half of the ethane is removed from the reaction container. Which direction will the reaction proceed to re-establish equilibrium, L to R or R to L. Support your prediction with a short explanation. (6)

d)The ΔH° for the reaction above is +158 kJ mol^{-1}. Under what conditions of temperature (high T or low T) will the reaction above produce the most amount of product? Explain. (5)

4. (CONTINUED)

e) Under what conditions of pressure (high P or low P) will the reaction above produce the most amount of product? Explain. (5)

(18) 5. Complete the following short answer questions:

a) Given the following substance behaves as an acid, write the formula of its conjugate base. (2)

$HC_3H_5O_2$ _____
Acid conjugate base

b) Write a balanced chemical equation showing how the substance you identified as a base in 6a behaves as a base when added to water. (4)

c) The value of K for the reaction

$$NH_4^{+}(aq) + NO_2^{-}(aq) \rightarrow NH_3(aq) + HNO_2(aq)$$

is less than one. Write the formula for the strongest acid and strongest base in the reaction. (4)

c) A particular solution has a $[OH^-] = 7.00 \times 10^{-9}$ M. Calculate $[H^+]$, pH and pOH of this solution. Is this solution acid or basic? (8)

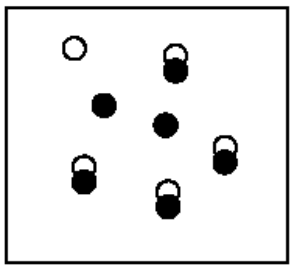
Multiple Choice: (12 points)

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

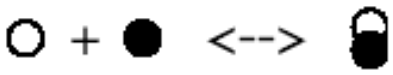
10. _____ 11. _____ 12. _____

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

11. The following diagram represents a reaction chamber



where the chemical reaction,

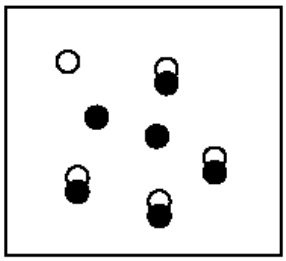


is at equilibrium

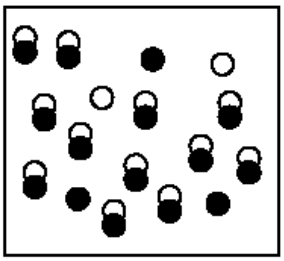
If nine units of

are added to the reaction chamber, which of the following best represents the system when it reestablishes equilibrium?

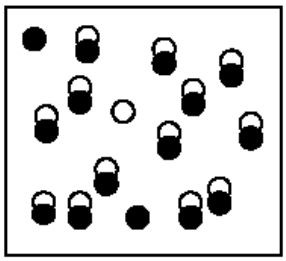
A.



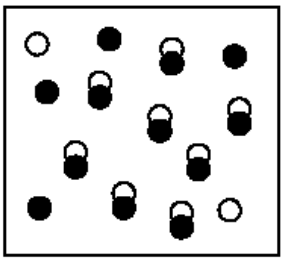
B.



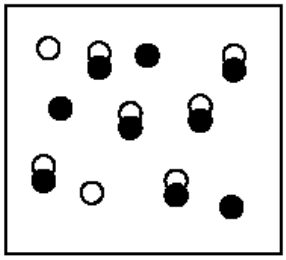
C.



D.



E.

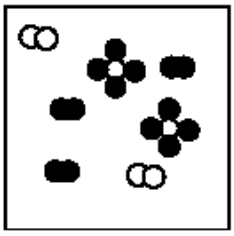


12. Consider the following hypothetical reaction:

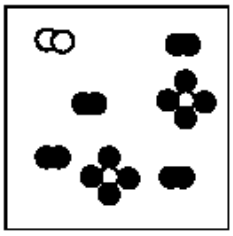
$$A_{2(g)} + 4B_{2(g)} \text{ ä } 2AB_{4(g)}$$

Initially 3 molecules of A_2 and 7 molecules of B_2 are placed in a reaction vessel. After a period of time 2 molecules of AB_4 are found in the vessel. Which of the following diagrams represents this final state?

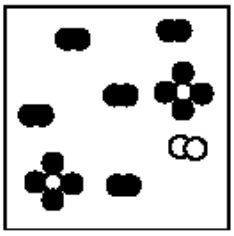
A.



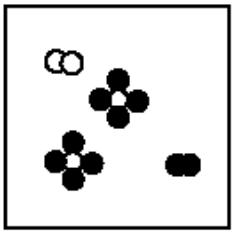
B.



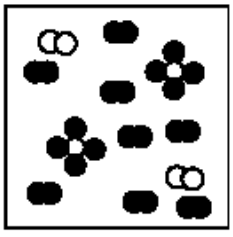
C.



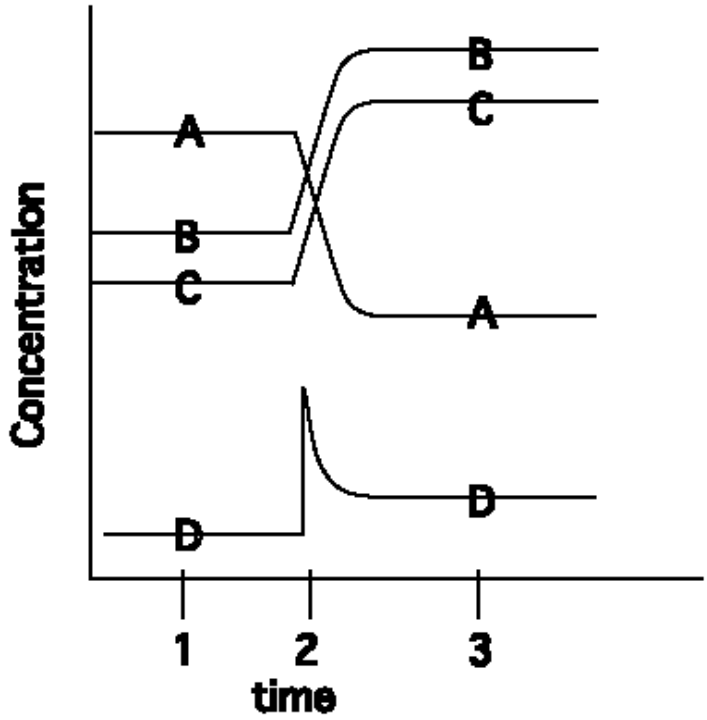
D.



E.



13. The following diagram represents a hypothetical chemical reaction



At time 2 a change takes place in the reaction. Which of the following statements about this chemical system is false?

A) At time 3 the system is at equilibrium.
B) At time 2 the concentration of D was increased
C) The change at time 2 caused more C to be formed.
D) The diagram is an illustration of the effect that changing the concentration has on a reaction at equilibrium
E) D and A are on opposite sides of the equation representing the reaction

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 **Rf** (261)	105 **Db** (262)	106 **Sg** (266)	107 **Bh** (264)	108 **Hs** (269)	109 **Mt** (268)	110 (271)	111 (272)	112 (277)		114 (285)		116 (289)		

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

$PV = nRT$ $\quad R = 0.0821 \frac{L \cdot atm}{mol \cdot K} = 8.314 \frac{J}{mol \cdot K}$ $\quad 6.02 \times 10^{23}$

density of $H_2O = 1.00 \frac{g}{cm^3}$

$pH = -\log[H^+]$ $\quad pOH = -\log [OH^-]$

$pH + pOH = 14$

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

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

$x_{1,2} = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$ 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}	
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

Activity Series

Metal	Half-Reaction Reaction
Gold	$Au^{3+} + 3e^- \rightarrow Au$
Platinum	$Pt^{2+} + 2e^- \rightarrow Pt$
Mercury	$Hg^{2+} + 2e^- \rightarrow Hg$
Silver	$Ag^+ + e^- \rightarrow Ag$
Copper	$Cu^{2+} + 2e^- \rightarrow Cu$
Hydrogen	$2H^+ + 2e^- \rightarrow H_2$
Lead	$Pb^{2+} + 2e^- \rightarrow Pb$
Tin	$Sn^{2+} + 2e^- \rightarrow Sn$
Nickel	$Ni^{2+} + 2e^- \rightarrow Ni$
Cobalt	$Co^{2+} + 2e^- \rightarrow Co$
Iron	$Fe^{2+} + 2e^- \rightarrow Fe$
Chromium	$Cr^{3+} + 3e^- \rightarrow Cr$
Zinc	$Zn^{2+} + 2e^- \rightarrow Zn$
Manganese	$Mn^{2+} + 2e^- \rightarrow Mn$
Aluminum	$Al^{3+} + 3e^- \rightarrow Al$
Magnesium	$Mg^{2+} + 2e^- \rightarrow Mg$
Sodium	$Na^+ + e^- \rightarrow Na$
Calcium	$Ca^{2+} + 2e^- \rightarrow Ca$
Barium	$Ba^{2+} + 2e^- \rightarrow Ba$
Potassium	$K^+ + e^- \rightarrow K$
Lithium	$Li^+ + e^- \rightarrow Li$