

Key

Name (please print)

CHEMISTRY 128
HOOR TEST 2
June 19, 2009

USEFUL INFORMATION:

$$N = 6.022 \times 10^{23} \quad R = 0.08206 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}} = 0.0083145 \frac{\text{kJ}}{\text{mol} \cdot \text{K}} \quad K_w = 1 \times 10^{-14}$$

$$\text{pH} = -\log[\text{H}_3\text{O}^+] \quad \text{pK}_a = -\log(\text{K}_a) \quad \text{pOH} = -\log[\text{OH}^-] \quad K_w = [\text{H}_3\text{O}^+][\text{OH}^-]$$

$$K_w = (\text{K}_a)(\text{K}_b) \quad \text{pH} = \text{pK}_a + \log\left(\frac{[\text{A}^-]}{[\text{HA}]}\right) \quad y = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

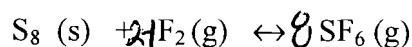
1 IA	2												13	14	15	16	17	18 VIIIA		
1 H 1.008	2 He 4.00												3 Li 6.94	4 Be 9.01	5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
11 Na 22.99	12 Mg 24.31	3	4	5	6	7	8	9	10	11	12	13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.06	17 Cl 35.45	18 Ar 39.95			
19 K 39.10	20 Ca 40.08	21 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 58.71	29 Cu 63.54	30 Zn 65.37	31 Ga 69.72	32 Ge 72.59	33 As 74.92	34 Se 78.96	35 Br 79.91	36 Kr 83.30			
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 98.91	44 Ru 101.07	45 Rh 102.91	46 Pd 106.4	47 Ag 107.87	48 Cd 112.40	49 In 114.82	50 Sn 118.69	51 Sb 121.75	52 Te 127.60	53 I 126.90	54 Xe 131.30			
55 Cs 132.91	56 Ba 137.34	71 Lu 174.97	72 Hf 178.49	73 Ta 180.95	74 W 183.85	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.09	79 Au 196.97	80 Hg 200.59	81 Tl 204.37	82 Pb 207.19	83 Bi 208.98	84 Po 210	85 At 210	86 Rn 222			
87 Fr 223	88 Ra 226.03	103 Lr 262.1	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt												

57 La 138.91	58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm 146.92	62 Sm 150.35	63 Eu 151.96	64 Gd 157.25	65 Tb 158.92	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.04
89 Ac 227.03	90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np 237.05	94 Pu 239.05	95 Am 241.06	96 Cm 247.07	97 Bk 249.08	98 Cf 251.08	99 Es 254.09	100 Fm 257.10	101 Md 258.10	102 No 255

There Are 6 Pages On This Test Including This Cover Page.
The Test Contains 100 Points.

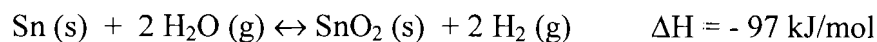
I. (45 points) Short Answers

1. (4 pts) Write the K_p for the following unbalanced reaction.



$$K_p = \frac{(P_{SF_6})^8}{(P_{F_2})^{24}}$$

2. (2 pts) K_c must be (Circle one: **less than, equal to, greater than**) one in order to favor product formation.
3. (2 pts) If Q is greater than K_c , the concentrations of the reactants must (Circle one: **increase, decrease**) in order for the system to reach equilibrium.
4. (9 pts) Indicate, by circling the correct answer, the effect of the following changes on the position of the equilibrium; that is, state which way the equilibrium will shift (left, no change, or right).



- a. Addition of more $SnO_2 (s)$ (left, **no change**, right)
- b. Increasing the volume of the container (left, **no change**, right)
- c. Cooling the reaction (left, no change, **right**)
5. (4 points) The conjugate base of HSO_4^- is SO_4^{2-} and the conjugate acid of HSO_4^- is H_2SO_4 .

6. (6 points) Given the following, circle the stronger acid in each row.

a. **HOCN** ($pK_a = 3.46$) vs. HCN ($pK_a = 9.40$)

b. **HClO₄** vs. H₃PO₄

7. (4 points) Circle the weak acid(s) and underline the weak base(s) of the following list.

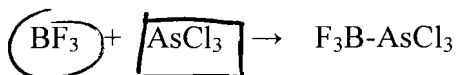
KOH

(CH₃)₃NH⁺

NaCN

HNO₃

8. (4 points) In the following reaction, circle the Lewis acid and put a box around the Lewis base.



9. (4 points) What is the $[OH^-]$ of a $Mg(OH)_2$ solution, if the solution has a pH of 9.51?

$$pOH = 14 - pH = 4.49$$

$$[OH^-] = \underline{3.2 \times 10^{-5}}$$

$$[OH^-] = 10^{-pOH} = 10^{-4.49} = 3.2 \times 10^{-5}$$

10. (10 points) Complete the following table.

Chemical Formula	Ions immediately formed when dissolved in H ₂ O	Reaction of each ion, if any, with H ₂ O (Write NR if no reaction)
Li ₂ S	Li ⁺ S ²⁻	Li ⁺ + H ₂ O → NR S ²⁻ + H ₂ O → HS ⁻ + OH ⁻
CaI ₂	Ca ²⁺ I ⁻	Ca ²⁺ + H ₂ O → NR I ⁻ + H ₂ O → NR

11. (9 points) Indicate by circling the correct answer if a 0.10 M solution is acidic, basic, or neutral.

a. Na₂SO₄ (acidic, neutral, basic)

b. Al(ClO₄)₃ (acidic, neutral, basic)

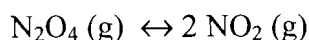
c. NH₄CN (acidic, neutral, basic)

$$K_a \text{ for } \text{NH}_4^+ = 5.6 \times 10^{-10}$$

$$K_b \text{ for } \text{CN}^- = 2.5 \times 10^{-5}$$

II. (55 points) Calculations. Show clear, complete setup for full credit.

12. (11 points) A quantity of 2.75 g of N₂O₄ was placed in an evacuated 1.50 L flask. At equilibrium, the flask contained some amount of N₂O₄ and 2.11 g NO₂.



Calculate K_c for this process

$$[\text{N}_2\text{O}_4]_{\text{init}} = 2.75 \text{ g N}_2\text{O}_4 \times \frac{1 \text{ mol N}_2\text{O}_4}{92.02 \text{ g N}_2\text{O}_4} \times \frac{1}{1.50 \text{ L}} = 0.0199$$

$$K_c = \underline{0.20}$$

$$[\text{NO}_2]_{\text{equil}} = 2.11 \text{ g NO}_2 \times \frac{1 \text{ mol NO}_2}{46.01 \text{ g NO}_2} \times \frac{1}{1.50 \text{ L}} = 0.0306$$

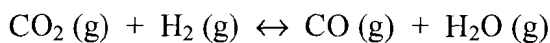
	$\text{N}_2\text{O}_4(\text{g})$	\rightleftharpoons	$2 \text{NO}_2(\text{g})$
Initial	0.0199		0
Change	$-\frac{1}{2}(0.0306)$		$+0.0306$
Equil	0.0046		0.0306

$$K_c = \frac{[\text{NO}_2]^2}{[\text{N}_2\text{O}_4]}$$

$$K_c = \frac{[0.0306]^2}{[0.0046]}$$

$$K_c = 0.20$$

13. (12 points) A chemical engineer is trying to convert "useless" CO_2 into the chemically important compound CO via the following process.



An experiment was performed in a 2.00 L flask at 686°C , and the equilibrium concentrations were found to be $[\text{CO}_2] = 0.086 \text{ M}$, $[\text{H}_2] = 0.086 \text{ M}$, $[\text{H}_2\text{O}] = 0.040 \text{ M}$, and $[\text{CO}] = 0.096 \text{ M}$.

- a) Calculate K_c for this process at 720°C .

$$K_c = \frac{[\text{CO}][\text{H}_2\text{O}]}{[\text{CO}_2][\text{H}_2]} = \frac{[0.096][0.040]}{[0.086][0.086]} = 0.52$$

$$K_c \underline{0.52}$$

- b) If 2.02 g H_2O is added to the system, what will the concentrations of all of the gases be when equilibrium is reestablished?

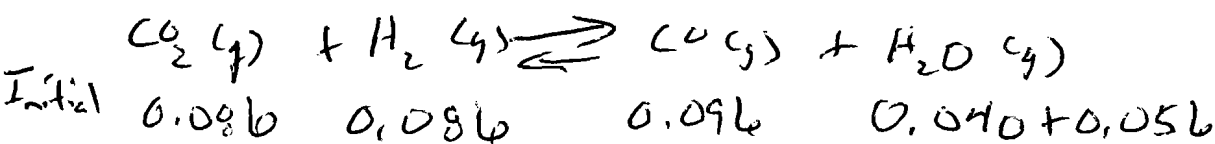
$$[\text{H}_2\text{O}]_{\text{added}} = 2.02 \text{ g H}_2\text{O} \times \frac{1 \text{ mol H}_2\text{O}}{18.02 \text{ g H}_2\text{O}} \times \frac{1}{2.00 \text{ L}} = 0.0561 \text{ M}$$

$$[\text{CO}] \underline{0.076 \text{ M}}$$

$$[\text{H}_2\text{O}] \underline{0.076 \text{ M}}$$

$$[\text{CO}_2] \underline{0.106 \text{ M}}$$

$$[\text{H}_2] \underline{0.106 \text{ M}}$$



$$K_c = \frac{[\text{CO}][\text{H}_2\text{O}]}{[\text{CO}_2][\text{H}_2]} = 0.52 = \frac{[0.096 - y][0.096 - y]}{[0.086 + y][0.086 + y]}$$

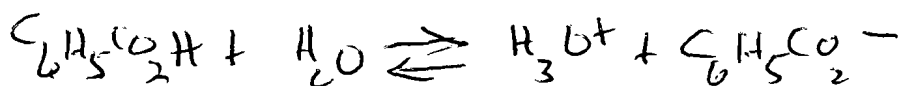
$$\sqrt{0.52} = \sqrt{\frac{[0.096 - y]^2}{[0.086 + y]^2}}$$

$$0.72 = \frac{0.096 - y}{0.086 + y}$$

$$0.062 + 0.72y = 0.096 - y$$

$$y = 0.020$$

14. (8 points) Determine the pH of a 0.23 M solution of benzoic acid $C_6H_5CO_2H$ ($K_a = 6.46 \times 10^{-5}$).



pH 2.41

Initial 0.23

0

0

Change $-y$

$+y$

$+y$

Equil 0.23 $-y$

y

y

$$K_a = \frac{[H_3O^+][C_6H_5CO_2^-]}{[C_6H_5CO_2H]}$$

$$6.46 \times 10^{-5} = \frac{[y][y]}{[0.23 - y]}$$

$$6.46 \times 10^{-5} = \frac{y^2}{0.23} \quad \text{Assuming } y \text{ is small}$$

$$y = [H_3O^+] = \sqrt{(6.46 \times 10^{-5})(0.23)}$$

$$y = [H_3O^+] = 3.85 \times 10^{-3} \text{ M}$$

$$\text{pH} = -\log(3.85 \times 10^{-3}) = 2.41$$

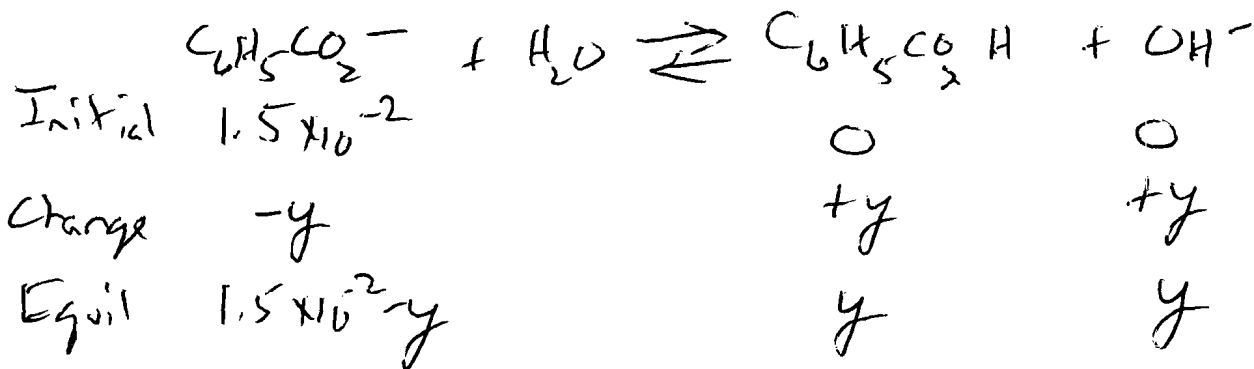
Checking the approximation...

$$\% \text{ Ionization} = \left(\frac{3.85 \times 10^{-3}}{0.23} \right) 100 = 1.7\%$$

15. (11 points) Calculate the pH of the solution that is formed when 0.54 g potassium benzoate ($C_6H_5CO_2K$) is dissolved in enough water to make 225 mL of solution.

pH 8.18

$$[C_6H_5CO_2K] = 0.54 \text{ g } C_6H_5CO_2K \times \frac{1 \text{ mol } C_6H_5CO_2K}{160.22 \text{ g } C_6H_5CO_2K} \times \frac{1}{0.225 \text{ L}} = 1.5 \times 10^{-2} \text{ M}$$



$$K_b = \frac{K_w}{K_a} = \frac{[C_6H_5CO_2H][OH^-]}{[C_6H_5CO_2^-]}$$

$$1.55 \times 10^{-10} = \frac{1 \times 10^{-14}}{6.46 \times 10^{-5}} = \frac{[y][y]}{[1.5 \times 10^{-2} - y]}$$

$$1.55 \times 10^{-10} = \frac{y^2}{1.5 \times 10^{-2}} \quad \text{Assuming } y \text{ is small}$$

$$\sqrt{(1.55 \times 10^{-10})(1.5 \times 10^{-2})} = y = [OH^-] = 1.5 \times 10^{-6}$$

Checking the approximation...

$$\% \text{ Ionization} = \left(\frac{1.5 \times 10^{-6}}{1.5 \times 10^{-2}} \right) 100 = 0.01\%$$

$$pOH = -\log(1.5 \times 10^{-6}) = 5.82$$

$$pH = 14 - pOH = 8.18$$