Key

Name (please print)

CHEMISTRY 128
HOUR TEST 2
June 19, 2009

USEFUL INFORMATION:

$N = 6.022 \times 10^{23}$ $\quad R = 0.08206 \frac{L \cdot atm}{mol \cdot K} = 0.0083145 \frac{kJ}{mol \cdot K}$ $\quad K_w = 1x10^{-14}$

$pH = -\log[H_3O^+]$ $\quad pK_a = -\log(K_a)$ $\quad pOH = -\log[OH^-]$ $\quad K_w = [H_3O^+]*[OH^-]$

$K_w = (K_a)*(K_b)$ $\quad pH = pKa + \log\left(\frac{[A-]}{[HA]}\right)$ $\quad y = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

1 IA																	18 VIIIA
1 **H** 1.008	2 IIA											13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	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 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8 ⌐	9 VIIIB	10 ¬	11 IB	12 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
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 <u>6</u> Pages On This Test Including This Cover Page.
The Test Contains <u>100</u> Points.

I. (45 points) Short Answers

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

$$S_8\ (s) + F_2\ (g) \leftrightarrow SF_6\ (g)$$

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

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).

$$Sn\ (s) + 2\ H_2O\ (g) \leftrightarrow SnO_2\ (s) + 2\ H_2\ (g) \qquad \Delta H = -97\ kJ/mol$$

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. $HClO_4$ vs. H_3PO_4

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

KOH $(CH_3)_3NH^+$ NaCN HNO_3

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

$$BF_3 + AsCl_3 \rightarrow F_3B\text{-}AsCl_3$$

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

$[OH^-]$ 3.2×10^{-5}

$pOH = 14 - pH = 4.49$

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

10. (10 points) Complete the following table.

Chemical Formula	Ions immediately formed when dissolved in H_2O	Reaction of each ion, if any, with H_2O (Write NR if no reaction)
Li_2S	Li^+ S^{2-}	$Li^+ + H_2O \rightarrow NR$ $S^{2-} + H_2O \rightarrow HS^- + OH^-$
CaI_2	Ca^{2+} I^-	$Ca^{2+} + H_2O \rightarrow NR$ $I^- + H_2O \rightarrow NR$

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

a. Na_2SO_4 (acidic, (neutral), basic)

b. $Al(ClO_4)_3$ ((acidic), neutral, basic)

c. NH_4CN (acidic, neutral, (basic))

K_a for $NH_4^+ = 5.6 \times 10^{-10}$
K_b for $CN^- = 2.5 \times 10^{-5}$

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

12. (11 points) A quantity of 2.75 g of N_2O_4 was placed in an evacuated 1.50 L flask. At equilibrium, the flask contained some amount of N_2O_4 and 2.11 g NO_2.

$$N_2O_4\,(g) \leftrightarrow 2\,NO_2\,(g)$$

Calculate K_c for this process

K_c 0.20

$[N_2O_4]_{initial} = 2.75\,g\,N_2O_4 \times \frac{1\,mol\,N_2O_4}{92.02\,g\,N_2O_4} \times \frac{1}{1.50\,L} = 0.0199$

$[NO_2]_{equil} = 2.11\,g\,NO_2 \times \frac{1\,mol\,NO_2}{46.0\,g\,NO_2} \times \frac{1}{1.50\,L} = 0.0306$

$N_2O_4(g) \rightleftharpoons 2\,NO_2(g)$

	N_2O_4	NO_2
Initial	0.0199	0
Change	$-\frac{1}{2}(0.0306)$	$+0.0306$
Equil	0.0046	0.0306

$K_c = \frac{[NO_2]^2}{[N_2O_4]}$

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

$K_c = 0.20$

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

$$CO_2\,(g) + H_2\,(g) \leftrightarrow CO\,(g) + H_2O\,(g)$$

An experiment was performed in a 2.00 L flask at 686°C, and the equilibrium concentrations were found to be $[CO_2] = 0.086$ M, $[H_2] = 0.086$ M, $[H_2O] = 0.040$ M, and $[CO] = 0.096$ M.

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

$$K_c = \frac{[CO][H_2O]}{[CO_2][H_2]} = \frac{[0.096][0.040]}{[0.086][0.086]} = 0.52$$

K_c 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?

$$[H_2O]_{added} = 2.02\,g\,H_2O \times \frac{1\,mol\,H_2O}{18.0\,g\,H_2O} \times \frac{1}{2.00\,L} = 0.0561\,M$$

[CO] 0.076 m

[H_2O] 0.076 m

[CO_2] 0.106 m

[H_2] 0.106 m

	$CO_2(g)$	+ $H_2(g)$	⇌ $CO(g)$	+ $H_2O(g)$
Initial	0.086	0.086	0.096	0.040 + 0.056
Change	+y	+y	−y	−y
Equil	0.086 + y	0.086 + y	0.096 − y	0.096 − y

$$K_c = \frac{[CO][H_2O]}{[CO_2][H_2]} = 0.52 = \frac{[0.096 - y][0.096 - y]}{[0.086 + y][0.086 + y]}$$

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

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

$$0.062 + 0.72y = 0.096 - y \qquad y = 0.020$$

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

$C_6H_5CO_2H + H_2O \rightleftharpoons H_3O^+ + C_6H_5CO_2^-$

	$C_6H_5CO_2H$	H_3O^+	$C_6H_5CO_2^-$
Initial	0.23	0	0
Change	$-y$	$+y$	$+y$
Equil	$0.23 - y$	y	y

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

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

$$6.46 \times 10^{-5} = \frac{y^2}{0.22}$$

Assuming y is small

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

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

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

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

$$[C_6H_5CO_2K] = 0.54\,g\,C_6H_5CO_2K \times \frac{1\,mol\,C_6H_5CO_2K}{160.22\,g\,C_6H_5CO_2K} \times \frac{1}{0.225\,L} = 1.5\times10^{-2}\,M$$

$$C_6H_5CO_2^- + H_2O \rightleftharpoons C_6H_5CO_2H + OH^-$$

	$C_6H_5CO_2^-$	$C_6H_5CO_2H$	OH^-
Initial	1.5×10^{-2}	0	0
Change	$-y$	$+y$	$+y$
Equil	$1.5\times10^{-2}-y$	y	y

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

$$1.55\times10^{-10} = \frac{1\times10^{-14}}{6.46\times10^{-5}} = \frac{[y][y]}{[1.5\times10^{-2}-y]}$$

$$1.55\times10^{-10} = \frac{y^2}{1.5\times10^{-2}}$$ Assuming y is small

$$\sqrt{(1.55\times10^{-10})(1.5\times10^{-2})} = y = [OH^-] = 1.5\times10^{-6}$$

Checking the approximation....

$$\%\,\text{Ionization} = \left(\frac{1.5\times10^{-6}}{1.5\times10^{-2}}\right)100$$

$$= 0.01\%$$

$$pOH = -\log(1.5\times10^{-6})$$

$$= 5.82$$

$$pH = 14 - pOH = 8.18$$