Key

Name (please print)

CHEMISTRY 128
HOUR TEST 2
June 20, 2003

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. (6 points) Circle the stronger acid.

   a. HF vs. HI

   b. HCO_3^- ($K_a = 4.8x10^{-11}$) vs. HPO_4^{2-} ($K_a = 3.6x10^{-13}$)

2. (6 points) Complete the following table.

Conjugate Acid	Conjugate Base
HSO_3^-	SO_3^{2-}
H_2CO_3	HCO_3^-

3. (4 points) Circle the strong acid(s) and put a box around the strong base(s) of the following list.

   H_3PO_4 NCl_3 H_2SO_4 LiOH

4. (9 points) Indicate by circling the correct answer if a 0.10 M solution is acidic, basic, or neutral.

   a. K_2CO_3 (acidic, neutral, basic)

   b. NH_4NO_3 (acidic, neutral, basic)

   c. NaBr (acidic, neutral, basic)

5. (8 points) Answer the following:

   a. What ions immediately form when K_2HPO_4 dissolves in H_2O?

   K^+, HPO_4^{2-}

   b. Write out the reaction of each ion from part a, if any, with H_2O (Write NR if no reaction).

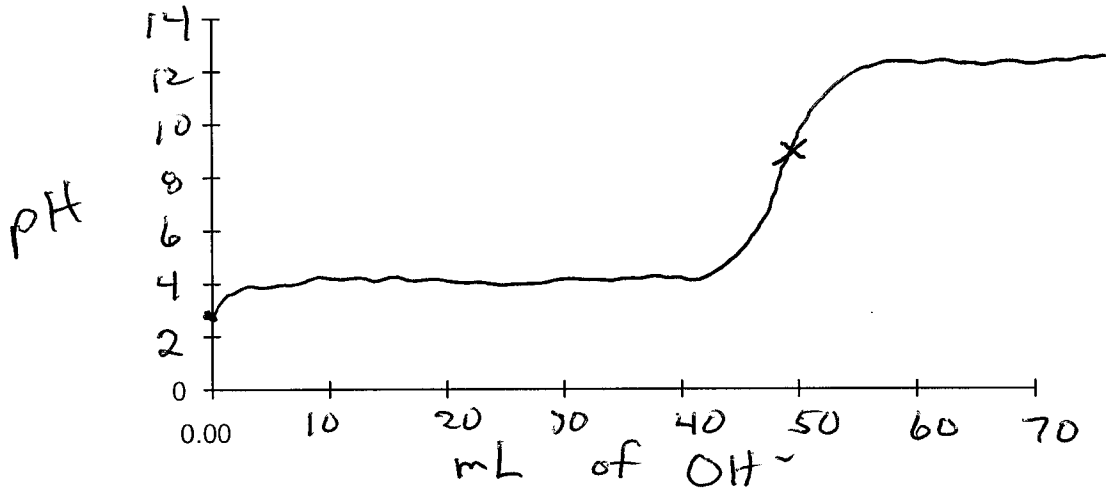
   $K^+ + H_2O \rightarrow NR$

   $HPO_4^{2-} + H_2O \rightarrow H_2PO_4^- + OH^-$

6. (4 points) In the following reaction, circle the Lewis acid and put a box around the Lewis base.

   $H_2O + CO_2 \rightarrow H_2CO_3$

7. (8 points) Sketch a curve showing pH as a function of the added volume of NaOH solution for the titration of 25.00 mL of 0.050 M benzoic acid ($C_6H_6O_2H$, $K_a = 6.8 \times 10^{-5}$) with 0.025 M NaOH. Label the axes. Do NOT do hard-core calculations. Simply approximate the pH of the 4 regions of the curve. On the curve, mark the approximate equivalence point with an X.



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

8. (8 points) Calculate the pH of a 0.250 M solution of glycolic acid ($HC_2H_3O_3$, $K_a = 1.48 \times 10^{-4}$)

$$HC_2H_3O_3 + H_2O \rightleftharpoons H_3O^+ + C_2H_3O_3^-$$

	$HC_2H_3O_3$	H_3O^+	$C_2H_3O_3^-$
Initial	0.250	0	0
Change	$-y$	$+y$	$+y$
Equil	$0.250 - y$	y	y

$$K_a = \frac{[H_3O^+][C_2H_3O_3^-]}{[HC_2H_3O_3]} \qquad 1.48 \times 10^{-4} \approx \frac{[y][y]}{[0.250 - y]}$$

Assuming y is small...

$$1.48 \times 10^{-4} = \frac{y^2}{0.250}$$

$$6.08 \times 10^{-3} = \sqrt{(1.48 \times 10^{-4})(0.250)} = y = [H_3O^+]$$

Checking the approx.

$$\%\ \text{Ionization} = \left(\frac{6.08 \times 10^{-3}}{0.250}\right) 100 = 2.4\%$$

$$pH = -\log[H_3O^+]$$

$$pH = -\log[6.08 \times 10^{-3}] = 2.21$$

9. (8 points) Calculate the pH of a 0.00430 M solution of $Ca(OH)_2$.

$$Ca(OH)_2 \longrightarrow Ca^{2+} + 2OH^-$$

	$Ca(OH)_2$	Ca^{2+}	$2OH^-$
Initial	0.0043	0	0
Change	-0.0043	+0.0043	+2(0.0043)
Equil	0	0.0043	0.0086

$$pOH = -\log[OH^-] = -\log(0.0086) = 2.065$$

$$pH = 14 - pOH = 14 - 2.07 = 11.93$$

10. (10 points) Calculate the pH of a 0.025 M solution of C_5H_5NHCl given that the K_b of C_5H_5N is 1.5×10^{-9}.

$$C_5H_5\overset{+}{N}H + H_2O \rightleftharpoons C_5H_5N + H_3O^+$$

	$C_5H_5\overset{+}{N}H$	C_5H_5N	H_3O^+
Initial	0.025	0	0
Change	-y	+y	+y
Equil	0.025 - y	y	y

$$K_a = \frac{[C_5H_5N][H_3O^+]}{[C_5H_5\overset{+}{N}H]} = \frac{K_w}{K_b} = \frac{1\times10^{-14}}{1.5\times10^{-9}} = \frac{[y][y]}{[0.025-y]}$$

$$6.67\times10^{-6} = \frac{y^2}{0.025}$$ Assuming y is small

$$4.08\times10^{-4} = \sqrt{(6.67\times10^{-6})(0.025)} = y = [H_3O^+]$$

Checking the approx.

$$\%\ \text{Ionization} = \left(\frac{4.08\times10^{-4}}{0.025}\right)100 = 1.6\%$$

$$pH = -\log[H_3O^+]$$

$$pH = -\log[4.08\times10^{-4}]$$

$$pH = 3.39$$

11. (15 points) A 0.50 L sample of 0.30 M Concordic acid was found to have a pH of 2.25.

a. Calculate the K_a of Concordic acid.

$$HA + H_2O \rightleftharpoons H_3O^+ + A^-$$

	HA		H_3O^+		A^-
Initial	0.30		0		0
Change	-0.006		$+5.6\times10^{-3}$		$+5.6\times10^{-3}$
Equil	0.294		5.6×10^{-3}		5.6×10^{-3}

$[H_3O^+] = 10^{-pH}$

$[H_3O^+] = 10^{-2.25}$

$[H_3O^+] = 5.6\times10^{-3}$

$$K_a = \frac{[H_3O^+][A^-]}{[HA]} = \frac{[5.6\times10^{-3}][5.6\times10^{-3}]}{[0.0294]} = 1.08\times10^{-4}$$

b. When 61.7 g of the sodium salt of Concordic acid (sodium Concordide) was added to the solution of part a, the pH was found to be 4.14. Calculate the molecular mass (in grams/mole) of sodium Concordide.

$$pH = pK_a + \log\left(\frac{[Base]}{[Acid]}\right)$$

$$4.14 = -\log(1.08\times10^{-4}) + \log\left(\frac{[Base]}{[0.30]}\right)$$

$$4.14 = 3.97 + \log\left(\frac{[Base]}{0.30}\right)$$

$$0.17 = \log\left(\frac{[Base]}{0.30}\right)$$

$$1.48 = \frac{[Base]}{0.30}$$

$$0.444\ M = [Base] = \text{sodium Concordide}$$

$$\text{moles of base} = 0.444\ \frac{mol}{L} \times 0.50\ L = 0.222\ mol$$

$$mm_{Base} = \frac{g}{mol} = \frac{61.7\ g}{0.222\ mol} = 278\ \frac{g}{mol}$$

12. (14 pts) A 50.00 mL sample of 0.0250 M HCN ($K_a = 6.2 \times 10^{-10}$ M) is titrated with 25.00 mL of 0.0500 M NaOH, calculate the pH of the resulting solution.

	HCN	+ OH^-	$\rightarrow H_2O$ +	CN^-
Initial mmoles	$= (0.0250 \frac{mmol}{mL})(50.00 mL)$	$(0.0500 \frac{mmol}{mL})(25.00 mL)$		
	$= 1.25$ mmol	$= 1.25$ mmol		0 mmol
Change	$= -1.25$ mmol	-1.25 mmol		$+ 1.25$ mmol
Final mmol	$= 0$ mmol	0 mmol		1.25 mmol

	CN^-	+ $H_2O \rightleftharpoons$	HCN	+ OH^-
Initial	$= \frac{1.25 mmol}{75.00 mL} = 0.0167$ M		0	0
Change	$= -y$		$+y$	$+y$
Equil	$= 0.0167 - y$		y	y

$$K_b = \frac{[HCN][OH^-]}{[CN^-]} = \frac{K_w}{K_a} = \frac{1 \times 10^{-14}}{6.2 \times 10^{-10}} = \frac{[y][y]}{[0.0167 - y]} = \frac{y^2}{0.0167}$$

Assuming y is small

$$1.61 \times 10^{-5} = \frac{y^2}{0.0167}$$

$$\sqrt{(1.61 \times 10^{-5})(0.0167)} = y = [OH^-]$$

$$5.19 \times 10^{-4} = y = [OH^-]$$

Checking the approximation...

$$\% \text{ Ionization} = \left(\frac{5.19 \times 10^{-4}}{0.0250}\right) 100 = 2.1\%$$

$$pOH = -\log[OH^-] = -\log(5.19 \times 10^{-4}) = 3.28$$

$$pH = 14 - pOH = 14 - 3.28 = 10.72$$