Name _____ Test 3
PHYS 0111 (Gen Chem II) Spring 2005

A few equations:

$K = \frac{[\text{products}]}{[\text{reactants}]}$

$Q = \frac{[\text{products}]_o}{[\text{reactants}]_o}$

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

$pOH = -\log[OH^-]$

$pK_w = -\log(K_w)$

$pK_a = -\log(K_a)$

$K_w = [H_3O^+][OH^-]$

$pK_w = pH + pOH$

A few constants:

$K_w = 10^{-14}$

$pK_w = 14$

K_a values for a few acids

Acid	K_a	pK_a
HSO_4^-	1.2×10^{-2}	1.92
$HClO_2$	1.2×10^{-2}	1.92
H_3PO_4	7.5×10^{-3}	2.12
$CClH_2CO_2H$	1.35×10^{-3}	2.780
HF	7.2×10^{-4}	3.14
HNO_2	4.0×10^{-4}	3.40
CH_3CO_2H	1.8×10^{-5}	4.74
$[Al(H_2O)_6]^{3+}$	1.4×10^{-5}	4.85
$H_2PO_4^-$	6.2×10^{-8}	7.21
HOCl	3.5×10^{-8}	7.46
HCN	6.2×10^{-10}	9.21
NH_4^+	5.6×10^{-10}	9.25
HPO_4^{2-}	4.8×10^{-13}	12.32

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____

1. The equilibrium constant, K, for the following reaction is 0.26.

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3\,H_2(g)$$

CH_4, H_2O, CO, and H_2 are added to a reactor so that their concentrations are 0.14, 0.22, 0.10, and 0.033 M respectively.

a. (8 pts.) Determine Q for this reaction.

$$Q = \frac{(0.10)(0.033)^3}{(0.14)(0.22)} = 0.00011668$$

b. (6 pts.) Is this reaction at equilibrium? If the reaction is not at equilibrium, in which direction will the reaction proceed? Explain.

No, the reaction is not at equilibrium, the Q is too low. To raise Q, reactants must be converted to products until Q = K.

2. The equilibrium constant, K, for the following reaction is 7.5.

$$2\,NO_2\,(g) \rightleftharpoons N_2O_4\,(g) \qquad \Delta H = -58\ kJ$$

a. (4 pts.) Does this reaction favor the reactants or the products?

The products

b. (4 pts.) Which change would encourage more product formation, a decrease or an increase in the temperature?

a decrease in temperature

c. (4 pts.) What would happen to the concentration of N_2O_4 if some of the NO_2 condensed into a liquid?

The N_2O_4 would be consumed.

3. (4 pts. ea.) In the following reactions indicate whether the underlined molecule is acting as an acid or a base.

a. $HCl\ (aq) + \underline{H_2O}\ (l) \longrightarrow H_3O^+\ (aq) + Cl^-\ (aq)$ — base

b. $\underline{CH_3NH_2}\ (aq) + H_2O\ (l) \longrightarrow CH_3NH_3^+\ (aq) + OH^-\ (aq)$ — base

c. $\underline{HNO_3}\ (aq) + H_2O\ (l) \longrightarrow H_3O^+\ (aq) + Cl^-\ (aq)$ — acid

d. $NH_3\ (aq) + \underline{H_2O}\ (l) \longrightarrow NH_4^+\ (aq) + OH^-\ (aq)$ — acid

4. (4 pts. each) Determine the formulas for the following molecules.

a. The conjugate base of H_2O is HO^-

b. The conjugate acid of HSO_4^- is H_2SO_4

c. The conjugate base of $H_2PO_4^-$ is HPO_4^{2-}

d. The conjugate acid of H_2O is H_3O^+

5. The *n*-butyl anion, $CH_3CH_2CH_2CH_2^-$, is a very strong base.

a. (6 pts.) Write the balanced chemical equation for the reaction of this anion with water.

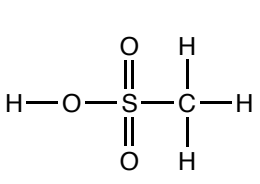
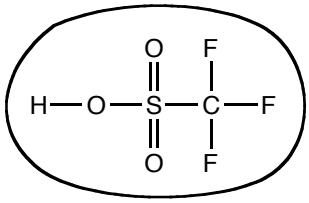
$$CH_3CH_2CH_2CH_2^-\ (aq) + H_2O\ (l) \rightleftharpoons CH_3CH_2CH_2CH_3\ (g) + OH^-\ (aq)$$

b. (6 pts.) Write the K_b expression for the reaction of $CH_3CH_2CH_2CH_2^-$ with H_2O.

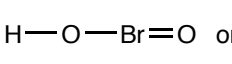
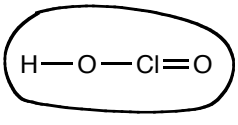
$$K_b = \frac{[OH^-][CH_3CH_2CH_2CH_3]}{[CH_3CH_2CH_2CH_2^-]}$$

6. (4 pts. each) For each of the following pairs of acids, identify (circle) the stronger acid.

a. H—I or H—Cl

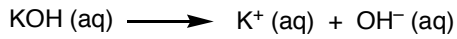
b.  or 

c. H—Br or H—F

d.  or 

Determine the pH of the following solutions.

7. (10 pts.) A 0.056 M KOH solution.



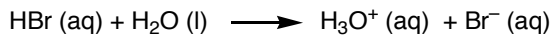
pOH = -log(0.056)

pKw = pH + pOH

14 = pH + 1.2518

pH = 12.75

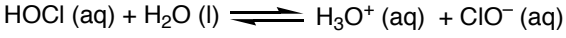
8. (10 pts.) A 0.44 M HBr solution.



pH = -log(0.44)

pH = 0.36

9. (10 pts.) A 0.36 M HOCl solution.



	HOCl	H_3O^+	ClO^-
i	0.36	~0	0
c	-x	+x	+x
e	0.36 - x	X	X

$x^2/(0.36 - x) = 3.5 \times 10^{-8}$ valid?

small x approx 0.36 - x = 0.36 0.00011225/0.36 * 100 = 0.031%

$x = [(3.5 \times 10^{-8})(0.36)]^{1/2} = 0.00011225$ yes

pH = -log(0.00011225) = 3.95

10. (8 pts.) Provide an explanation for the observation that HI is a stronger acid than HF.

The negative charge on an iodide ion is more diffuse than the negative charge on a fluoride ion (iodide is larger than fluoride). So, the iodide ion is not as strongly attracted to the H^+ in HI as the fluoride ion is attracted to the H^+ in HF.