

CHEM 1114 Exam 2, March 28, 2008

Name Key

By submitting this exam, you affirm that you have not received or given unauthorized aid.

Useful Information:  $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$ ,  $\text{pH} = -\log[\text{H}_3\text{O}^+]$ ,  $K_a \cdot K_b = K_w$ ,  $\text{pH} + \text{pOH} = 14.00$ ,

$PV = nRT$ ,  $R = 0.0821 \text{ L}\cdot\text{atm}/\text{mol}\cdot\text{K}$ ,  $8.314 \text{ J}/\text{mol}\cdot\text{K}$ ,  $K_w = 1.00 \times 10^{-14}$ ,  $(n/V) \cdot RT = P$ ,

$$\ln \frac{k_2}{k_1} = \frac{-E_a}{R} \left( \frac{1}{T_2} - \frac{1}{T_1} \right), \quad \ln \frac{[A]_t}{[A]_0} = -kt$$

(1)(4 points) Define the following

(a) A Lewis Base *An electron-pair donor*

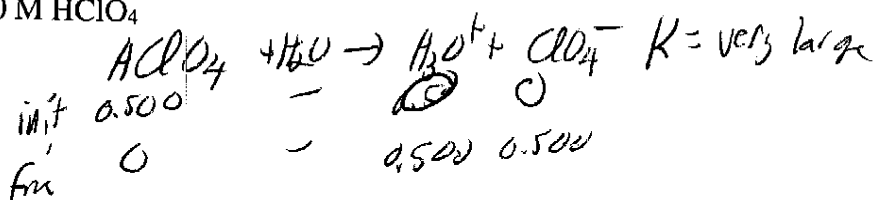
(b) A Lewis Acid *An electron-pair acceptor*

(c) A Brønsted-Lowry Base *an  $\text{H}^+$  acceptor*

(d) A Brønsted-Lowry Acid *an  $\text{H}^+$  donor*

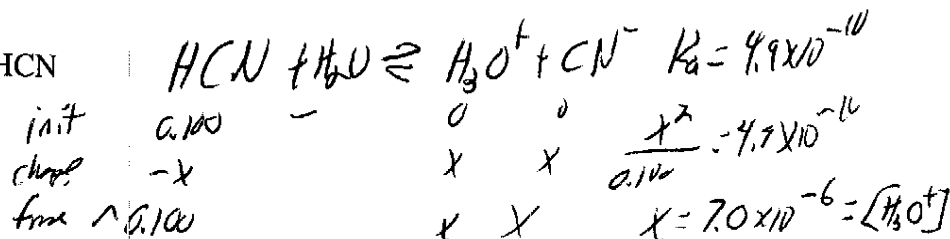
(2)(6 points) What is the pH of the following solutions?

(a) 0.500 M  $\text{HClO}_4$



$$\text{pH} = -\log(0.500) = 0.301$$

(b) 0.100 M HCN

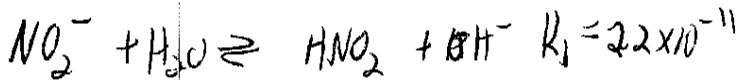


$$x = 7.0 \times 10^{-6} = [\text{H}_3\text{O}^+]$$

$$\text{pH} = -\log(7.0 \times 10^{-6}) = \boxed{5.15}$$

(c) 0.300 M NaNO<sub>2</sub>

$$NO_2^- K_b = \frac{1.00 \times 10^{-14}}{4.5 \times 10^{-4}} = 2.2 \times 10^{-11}$$



init	0.300	→	0	0	
change	-x		x	x	$\frac{x^2}{0.300} = 2.2 \times 10^{-11}$
final	≈ 0.300		x	x	x = 2.6 × 10 <sup>-6</sup>

$$pOH = -\log 2.6 \times 10^{-6} = 5.59$$

$$pH = 14.00 - 5.59 = \boxed{8.41}$$

(3)(4 points) Will the following salts be acidic, basic, or neutral

(a) LiNO<sub>2</sub> basic

(b) NH<sub>4</sub>CN ←  $\frac{1.00 \times 10^{-14}}{4.5 \times 10^{-4}} = 2.2 \times 10^{-11} = K_b$  basic

(c) NaOH basic

(d) CaCO<sub>3</sub> basic

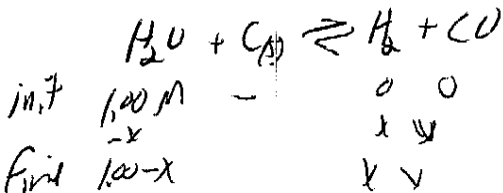
→ (4)(6 points) Given the following information



(a) Write the formula for K<sub>c</sub>.

$$K_c = \frac{[CO][H_2]}{[H_2O]}$$

(b) If 1.00 mole of H<sub>2</sub>O is contained in a 1.00 L vessel and allowed to react until equilibrium is established, what is [CO] at equilibrium?



$$\frac{x^2}{1.00 - x} = 55 \quad x = \frac{-55 \pm \sqrt{(55)^2 - 4(1)(55)}}{2}$$

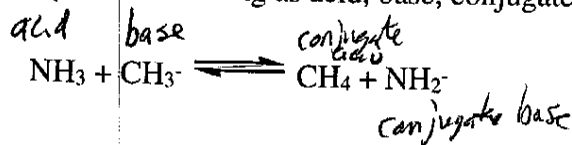
$$x^2 = 55 - 55x \quad x = \frac{-55 \pm 57.0}{2}$$

$$x^2 + 55x - 55 = 0 \quad x = 0.98$$

$$\boxed{[CO] = 0.98 M}$$

$$\frac{(0.98)^2}{0.02} = 50 \text{ is right}$$

(5)(2 points) Label the following as acid, base, conjugate acid, and conjugate base



(6)(4 points)

(a) what is the  $K_a$  of ammonium?

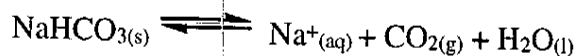
$$\text{NH}_4^+ \quad K_a = \frac{1.66 \times 10^{-14}}{1.8 \times 10^{-5}} = 5.6 \times 10^{-10}$$

(b) What is the  $K_b$  of sulfate?

$$K_b = \frac{1.00 \times 10^{-14}}{1.2 \times 10^{-2}} = 8.3 \times 10^{-13}$$

$K_a \text{ of } \text{HSO}_4^- = 1.2 \times 10^{-2}$

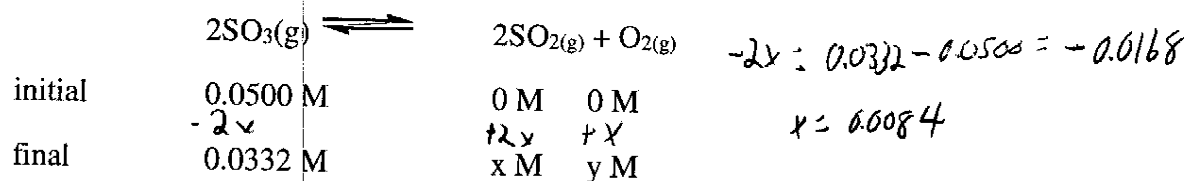
(7)(4 points) How will  $Q$  compare to  $K$  after the following procedures are performed on the equilibrium mixture (larger, smaller, equal to  $K$ )?



$$Q = \frac{[\text{Na}^+][\text{CO}_2]}{1}$$

- (a)  $\text{CO}_2$  is added to the system *larger*
- (b)  $\text{Na}^+$  is removed from the system *smaller*
- (c)  $\text{NaHCO}_3$  is added *equal to  $K$*
- (d)  $\text{N}_2$  is added *equal to  $K$*

(8)(4 points) For the following reaction, the initial and final concentrations are shown



(a) What are the values of  $x$  and  $y$ ?

$x = 0.0168 \text{ M}$      $0.0168 \text{ M}$   
 $y = 0.0084 \text{ M}$

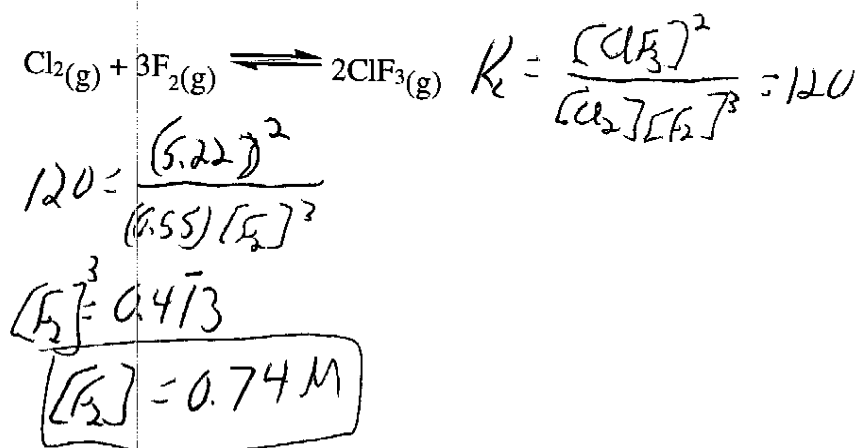
(b) What is the numerical value of  $K$ ?

$$K = \frac{(x)(2x)^2}{(0.0332)^2} = \frac{(0.0084)(0.0168)^2}{(0.0332)^2}$$

$4.25 \times 10^{-3}$

 $\text{or } 2.15 \times 10^{-3}$

(9)(4 points) For the reaction below,  $K_c = 120$ , If  $[\text{Cl}_2] = 0.55 \text{ M}$  and  $[\text{ClF}_3] = 5.22 \text{ M}$  at equilibrium, what is  $[\text{F}_2]$ ?



(10)(4 points) Place the following acids in order of increasing acidity.

$\text{PH}_3$ ,  $\text{HBr}$ ,  $\text{H}_2\text{S}$ ,  $\text{AlH}_3$

$\text{AlH}_3$ ,  $\text{PH}_3$ ,  $\text{H}_2\text{S}$        $\text{HBr}$

(11)(4 points) A solution is made by mixing  $\text{NH}_4\text{Cl}$  and  $\text{NH}_3$  in a 250 mL solution has a pH of 5.00. If the concentration of  $\text{NH}_4^+$  is 0.500 M, what is  $[\text{NH}_3]$ ?  $K_a = 5.6 \times 10^{-10}$  for  $\text{NH}_4^+$

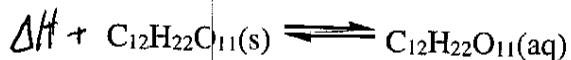


$$K_a = \frac{[\text{NH}_3][\text{H}_3\text{O}^+]}{[\text{NH}_4^+]} = 5.6 \times 10^{-10} \quad \begin{array}{l} [\text{NH}_4^+] = 0.500 \text{ M} \\ -\log[\text{H}_3\text{O}^+] = 5.00 \\ \therefore [\text{H}_3\text{O}^+] = 1.0 \times 10^{-5} \end{array}$$

$$K_a = \frac{[\text{NH}_3](1.0 \times 10^{-5})}{0.500} = 5.6 \times 10^{-10}$$

$$\boxed{[\text{NH}_3] = 2.8 \times 10^{-5}}$$

(12)(4 points) When a saturated solution of sucrose is cooled, solid sugar forms. Is the following reaction endothermic or exothermic and why?



$\frac{1}{2}$  for ans?

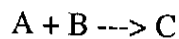
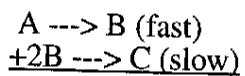
Endothermic. Heat is consumed in the forward rxn.

When the temp is lowered, the  $K$  shifts to favor

the reactants including heat.

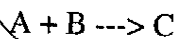
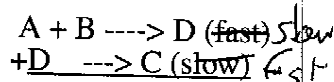
Extra Credit:(6 points) If the rate law of a reaction is found to be  $\text{rate} = k[A][B]$ , which of the following mechanisms are valid and why?

Mechanism 1



not supported  
rate determining step  $\text{rate} = k[B]^2$

Mechanism 2



Mechanism 2 is supported  
The rate determining step is  
 $\text{rate} = k[A][B]$ , same as the experimental  
rate