1. You make an 0.050M aqueous solution of benzoic acid, C_6H_5COOH. $K_a=6.5x10^{-5}$.

   a. Write the chemical equation describing this reaction.

   b. Write the K_a expression for this acid.

   c. Calculate the $[H_3O^+]$ and the pH of the solution (actual numbers needed)

2. 2.0 atm of a gas, $NOCl_2$, was heated in a 2.00 L container at 800 K. At equilibrium the partial pressure of Cl_2 was found to be 0.50 atm.

   The balanced chemical equation is: $NO(g)+ Cl_2(g) \leftrightarrow NOCl_2(g)$

   a. What is the partial pressure of the NO(g) at equilibrium?

   b. Show the setup of the problem that you would use to calculate K_p. Fill in all variables, but you do not need to calculate the final answer.

   c. Calculate the value of K_c for the reaction. Show the set up of the problem with all variables filled in.

3. Bleach has a pH of 11.5.

   a. What is the $[H_3O^+]$? Include the correct number of significant figures in your answer.

   b1. What is the [OH-] ?

   b2. What is the pOH?

   c. Is this liquid:
      a.Acidic
      b. More or less neutral
      c. Basic
      d. Can't tell directly from the pH

4. For the following salt: $PbCl_2$

   a. What is the weak acid or weak base produced when the salt hydrolyzes?

   b. Is the solution acidic, basic, neutral or you can't tell? Briefly explain.

   c. Write the chemical equation for the anion hydrolysis.

5. At 700 K, the reaction $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$ has the equilibrium constant $K_c = 4.3 \times 10^6$, and the following concentrations are present at the start of the reaction:
   $[SO_2] = 0.10$ M; $[SO_3] = 10.$ M; $[O_2] = 0.10$ M.

   a. Write the equilibrium constant expression for this reaction.

   b. According to Le Chatelier's principle, give 2 ways to shift the equilibrium toward products for this reaction.

   c. Calculate the equilibrium concentrations of the reactants in terms of x. You do not need to solve the algebra. Leave your answer in terms of x.

6. For the reaction: $CuO(s) + H_2(g) \rightleftharpoons H_2O(g) + Cu(s)$ Kp= 0.25 at 200°C

   a. Write the equilibrium constant expression.

   b. Calculate Kc for the reaction.

   c. A mass of CuO(s) is placed in a flask of $H_2(g)$ at a pressure of 2.0atm and allowed to achieve equilibrium at 200ºC. What is the pressure of the hydrogen at equilibrium?

7. For a 0.50 M solution of malonic acid ($H_2C_3H_2O_4$).
[For malonic acid, $K_{a1} = 1.4 \times 10^{-3}$, $K_{a2} = 2.0 \times 10^{-6}$.]

a. Calculate the pH of the solution.

b. Write the K_a expression for K_{a2}.

c. How important is K_{a2} to the calculation of pH? Explain briefly.

8. Reaction 1. $H_2C_2O_4(aq) \leftrightarrow C_2O_4^{2-}(aq) + 2H^+(aq)$, Kc= 0.40
Reaction 2. $H_2C_2O_4(aq) \leftrightarrow HC_2O_4^-(aq) + H^+(aq)$, Kc= 6.00

a. Calculate the equilibrium constant for the reaction: $HC_2O_4^-(aq) \leftrightarrow C_2O_4^{2-}(aq) + H^+(aq)$.

b. Calculate the equilibrium constant for the reaction: $2HC_2O_4^-(aq) \leftrightarrow 2C_2O_4^{2-}(aq) + 2H^+(aq)$

c1. Calculate the reaction quotient for Reaction 1 if all components are at a concentration of 1.5M.

c2. Will the reaction to toward products, toward reactants or not shift at all based on the initial concentrations of the components.

1. You make an 0.050M aqueous solution of benzoic acid, C_6H_5COOH. $K_a=6.5\times10^{-5}$.

a. Write the chemical equation describing this reaction.

$$C_6H_5COOH_{(aq)} + H_2O_{(l)} \rightleftharpoons C_6H_5COO^-_{(aq)} + H_3O^+_{(aq)}$$

b. Write the K_a expression for this acid.

$$K_a = \frac{[C_6H_5COO^-][H_3O^+]}{[C_6H_5COOH]}$$

c. Calculate the $[H_3O^+]$ and the pH of the solution (actual numbers needed)

	C_6H_5COOH	$C_6H_5COO^-$	H_3O^+
I	0.050	0	0
C	$-x$	$+x$	$+x$
E	$0.050-x$	x	x

$$K_a = \frac{(x)(x)}{(0.050-x)} = 6.5\times10^{-5} = \frac{x^2}{0.050}$$

ignore $0.050-x \approx 0.050$

$x^2 = 3.25\times10^{-6}$

$x = 1.803\times10^{-3}$

$[H_3O^+] = 1.8\times10^{-3}\,M$

$pH = -\log(1.803\times10^{-3}) = 2.74$

2. 2.0 atm of a gas, $NOCl_2$, was heated in a 2.00 L container at 800 K. At equilibrium the partial pressure of Cl_2 was found to be 0.50 atm.

The balanced chemical equation is: $NO(g) + Cl_2(g) \leftrightarrow NOCl_2(g)$

$$K_p = \frac{P_{NOCl_2}}{(P_{NO})(P_{Cl_2})}$$

a. What is the partial pressure of the NO(g) at equilibrium?

1:1 ratio so same as Cl_2 : 0.50 atm

b. Show the setup of the problem that you would use to calculate K_p. Fill in all variables, but you do not need to calculate the final answer.

	NO	Cl_2	$NOCl_2$
I	0	0	2.0
C	$+x$	$+x$	$-x$
E	0.50	0.50	2.0-0.50

$$K_p = \frac{(1.50)}{(0.50)(0.50)} = 6$$

c. Calculate the value of K_c for the reaction. Show the set up of the problem with all variables filled in.

$$K_p = K_c(R\cdot T)^{\Delta n}$$

$$\frac{(1.50)}{(0.50)^2} = K_c[(0.0821)\cdot(800)]^{-1}$$

$$6 = K_c(65.68)^{-1}$$

$$6 = K_c(0.01523)$$

$$K_c = 394$$

Note: on your exam you will be expected to calculate answers

3. Bleach has a pH of 11.5.

a. What is the $[H_3O^+]$? Include the correct number of significant figures in your answer.

$10^{-11.5} = 3 \times 10^{-12}$ M

b1. What is the [OH-] ?

$10^{-2.5} = 3 \times 10^{-3}$ M

b2. What is the pOH?

$14 - 11.5 = 2.5$

c. Is this liquid:

a. Acidic
b. More or less neutral
c. Basic
d. Can't tell directly from the pH

4. For the following salt: $PbCl_2$ not on exam 2 (this info will be on exam3)

a. What is the weak acid or weak base produced when the salt hydrolyzes?

Pb^{2+}

Cl^- → from HCl (strong acid) → no acid base properties

Pb^{2+} → from $PbOH^+$ (weak base) → can act as acid

b. Is the solution acidic, basic, neutral or you can't tell? Briefly explain.

acidic

c. Write the chemical equation for the anion hydrolysis.

$Cl^-_{(aq)} + H_2O_{(l)} \rightleftharpoons HCl_{(aq)} + OH^-_{(aq)}$

HCl is a strong acid, so this cannot occur.

5. At 700 K, the reaction $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$ has the equilibrium constant $K_c = 4.3 \times 10^6$, and the following concentrations are present at the start of the reaction:
$[SO_2] = 0.10$ M; $[SO_3] = 10.$ M; $[O_2] = 0.10$ M.

a. Write the equilibrium constant expression for this reaction.

$$K_{eq} = \frac{[SO_3]^2}{[SO_2]^2[O_2]}$$

b. According to Le Chatelier's principle, give 2 ways to shift the equilibrium toward products for this reaction.

Add SO_2 Remove SO_3
Add O_2

c. Calculate the equilibrium concentrations of the reactants in terms of x. You do not need to solve the algebra. Leave your answer in terms of x.

	SO_2	O_2	SO_3
I	0.10	0.10	10.
C	−2X	−X	+2X
E	0.10−2X	0.10−X	10.+2X

SO_2: $0.10-2X$
O_2: $0.10-X$

6. For the reaction: $CuO(s) + H_2(g) \rightleftharpoons H_2O(g) + Cu(s)$ Kp= 0.25 at 200°C +273.15
(CuO(s) not included; Cu(s) not included)

a. Write the equilibrium constant expression.

$$K_p = \frac{P_{H_2O}}{P_{H_2}}$$

b. Calculate Kc for the reaction.

$$K_p = K_c(R \cdot T)^{\Delta n} \qquad 0.25 = K_c(0.0821 \cdot 473.15)^{1} \qquad K_c = 0.25$$

c. A mass of CuO(s) is placed in a flask of $H_2(g)$ at a pressure of 2.0atm and allowed to achieve equilibrium at 200°C. What is the pressure of the hydrogen at equilibrium?

$$0.25 = \frac{P_{H_2O}}{P_{H_2}}$$

	H_2	H_2O
I	2.0	0
C	−X	+X
E	2.0−X	X

$$0.25 = \frac{X}{2.0-X}$$

$$0.5 - 0.25X = X$$

$$\frac{0.5}{1.25} = \frac{1.25X}{1.25}$$

$$X = 0.4$$

$P_{H_2} = 2.0 - 0.4 =$ **1.6 atm**

7. For a 0.50 M solution of malonic acid ($H_2C_3H_2O_4$). [For malonic acid, $K_{a1} = 1.4 \times 10^{-3}$, $K_{a2} = 2.0 \times 10^{-6}$.]

$H_2C_3H_2O_4(aq) + H_2O(l) \rightleftharpoons HC_3H_2O_4^-(aq) + H_3O^+(aq)$

$HC_3H_2O_4^-(aq) + H_2O(l) \rightleftharpoons C_3H_2O_4^{2-}(aq) + H_3O^+(aq)$

a. Calculate the pH of the solution.

$1.4 \times 10^{-3} = \frac{x^2}{(0.50 - x)} \approx \frac{x^2}{0.50}$ (ignore)

$x^2 = 7.0 \times 10^{-4}$

$x = 2.65 \times 10^{-2}$

$pH = -\log(2.65 \times 10^{-2})$

$= 1.58$

b. Write the K_a expression for K_{a2}.

$K_{a_2} = 2.0 \times 10^{-6} = \frac{[C_3H_2O_4^{2-}][H_3O^+]}{[HC_3H_2O_4^-]}$

only did calculation for 1st Ka because 2nd Ka is so small.

c. How important is K_{a2} to the calculation of pH? Explain briefly.

Not very → Ka 10^{-6} very small → very little dissociation occurs.

8. Reaction 1. $H_2C_2O_4(aq) \leftrightarrow C_2O_4^{2-}(aq) + 2H^+(aq)$, Kc= 0.40

Reaction 2. $H_2C_2O_4(aq) \leftrightarrow HC_2O_4^-(aq) + H^+(aq)$, Kc= 6.00

a. Calculate the equilibrium constant for the reaction: $HC_2O_4^-(aq) \leftrightarrow C_2O_4^{2-}(aq) + H^+(aq)$.

Add reactions → multiply Kvalues

~~$H_2C_2O_4(aq) \leftrightarrow C_2O_4^{2-}(aq) + 2H^+(aq)$~~

$HC_2O_4^-(aq) + H^+(aq) \rightleftharpoons H_2C_2O_4(aq)$ ← Reverse reaction take inverse of Kvalue

$HC_2O_4^-(aq) \rightleftharpoons C_2O_4^{2-}(aq) + H^+(aq)$ $K_c = \frac{1}{6} \times 0.40 = 6.7 \times 10^{-2}$

b. Calculate the equilibrium constant for the reaction: $2HC_2O_4^-(aq) \leftrightarrow 2C_2O_4^{2-}(aq) + 2H^+(aq)$

must reaction by coefficient, raise K to that power

$(6.7 \times 10^{-2})^2 = 4.4 \times 10^{-3}$

c1. Calculate the reaction quotient for Reaction 1 if all components are at a concentration of 1.5M.

$Q = \frac{[C_2O_4^{2-}][H^+]^2}{[H_2C_2O_4]} = \frac{[1.5][1.5]^2}{[1.5]} = 2.25$

c2. Will the reaction to toward products, toward reactants or not shift at all based on the initial concentrations of the components.

$2.25 > 0.40$

have too many products

reaction will shift toward reactants