

Chem 122 Rybolt Exam 2 Fall 2009 Name KEY (print)

Numerical constants may be listed below. Other needed information is given in the problem or written on the board or found in the periodic tables you will use during exam. For numerical problems, be sure to **show your work**, include units and circle your final answer. If several choices are given, **circle the correct answer**. Your written answers should be brief and to the point. You can use your own calculator on the exam, but no notes, books, external information, or other electronic devices are to be used. No cell phone is to be used in the Exam room.

1 cal = 4.184 J      R = 0.08206 (L atm/ mol K) or R= 8.31J/mol K

1 atm = 760 torr =  $1.01 \times 10^5$  N/m<sup>2</sup>      1 g =  $6.02 \times 10^{23}$  amu      °C = (°F-32)/1.8      K = °C + 273

pH + pOH = 14      [H<sup>+</sup>][OH<sup>-</sup>] =  $1 \times 10^{-14}$

1) For the reaction at equilibrium    heat + N<sub>2</sub>O<sub>4</sub> (colorless gas) ⇌ 2 NO<sub>2</sub> (brown gas) an increase in the temperature should cause a tube containing a mixture of these gases to

↑ →

- become darker brown     
  become lighter brown     
  remain unchanged

2) Consider the reaction N<sub>2</sub>(g) + O<sub>2</sub>(g) ⇌ 2 NO(g) which has an equilibrium constant of K=4.1×10<sup>-4</sup>. If the initial concentrations of nitrogen are 0.060M and oxygen is 0.020M and no NO is present then when equilibrium is reached the concentration of NO will be

|   |       |        |     |  |
|---|-------|--------|-----|--|
| I | .060  | .020   | 0   |  |
| C | -x    | -x     | +2x |  |
| E | .06-x | .020-x | 2x  |  |

$$K = \frac{[NO]^2}{[N_2][O_2]}$$

$$4.1 \times 10^{-4} = \frac{[2x]^2}{[.060-x][.020-x]}$$

$$4.1 \times 10^{-4} \approx \frac{4x^2}{[.060][.020]}$$

$$4.92 \times 10^{-7} \approx 4x^2$$

$$1.23 \times 10^{-7} \approx x^2$$

$$3.51 \times 10^{-4} \approx x$$

$[NO] = 2x = 7.0 \times 10^{-4} M$

3) Write the K<sub>p</sub> pressure equilibrium constant expression for the reaction for the formation of iron oxide given below 4Fe(s) + 3O<sub>2</sub>(g) ⇌ 2Fe<sub>2</sub>O<sub>3</sub>(s)

$$K_p = \frac{1}{P_{O_2}^3}$$

4) If the equilibrium constant K is a very large value then ΔG will be negative zero positive

$$\Delta G = -RT \ln K$$

5) If the equilibrium constant K is a very small fractional value then we would say products are favored reactants are favored ΔS=0

if K small then few products

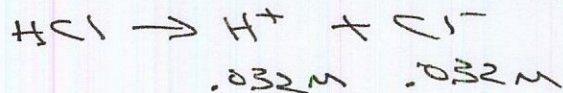
6) "Gastric acid is a secretion produced in the stomach. It is one of the main solutions secreted, together with several enzymes. Chemically it is an acid consisting mainly of hydrochloric acid and large quantities of potassium chloride and sodium chloride." wikipedia.org

A patient's stomach was found to contain a 0.032M solution of hydrochloric acid so therefore the pH of her stomach was:

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

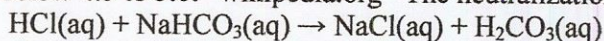
$$pH = -\log [0.032]$$

$$pH = -(-1.49)$$

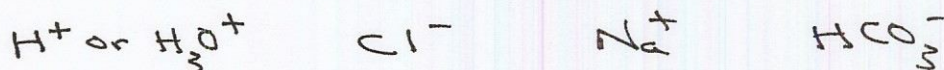


$$pH = 1.49 \quad \text{or } 1.5$$

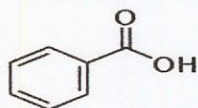
7) "In the duodenum, gastric acid is neutralized by sodium bicarbonate. This also blocks gastric enzymes that have their optima in the acid range of pH. The secretion of sodium bicarbonate from the pancreas is stimulated by secretin. This polypeptide hormone gets activated and secreted when the pH in duodenum falls below 4.5 to 5.0." wikipedia.org The neutralization is described above is expressed by the equation:



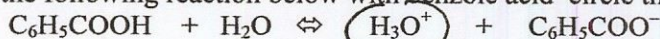
Write the ions (with correct charge) that are present on the left side of this reaction.



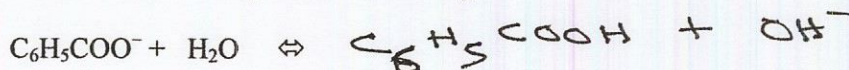
Consider the following for the next set of questions that deals with benzoic acid. "Benzoic acid,  $C_7H_6O_2$  (or  $C_6H_5COOH$ ), is a weak acid and its salts are used as a food preservative. Benzoic acid is an important precursor for the synthesis of many other organic substances. About 278 million pounds of benzoic acid are made each year. Benzoic acid inhibits the growth of mold, yeast and some bacteria. Benzoic acid is also used for the treatment of fungal skin diseases such as ringworm and athlete's foot. If the intracellular pH changes to 5 or lower, the anaerobic fermentation of glucose is decreased by 95%. The efficacy of benzoic acid and benzoate is thus dependent on the pH of the food. Acidified foods and drinks can be preserved with benzoic acid and benzoates." information from wikipedia.org



8) For the following reaction below with benzoic acid circle the Bronsted-Lowry conjugate acid of water



9) If  $NaC_6H_5COO$  is placed in water it produces  $Na^+$  and  $C_6H_5COO^-$ . And then there is a reaction with  $C_6H_5COO^-$  and water. Complete the following:



the conjugate base will pull  $H^+$  off water because equilibrium favors the unionized form of a weak acid

10) The pKa of benzoic acid is 4.21 and the corresponding Ka value of benzoic acid is  $6.17 \times 10^{-5}$ . A 0.222 M solution of benzoic acid would have what concentration of  $H^+$  at equilibrium.

$$HA \rightleftharpoons H^+ + A^-$$

$$.222 - x \quad x \quad x$$

$$K_a = \frac{[H^+][A^-]}{[HA]}$$

$$6.17 \times 10^{-5} = \frac{[x][x]}{[.222 - x]}$$

ignore so

$$6.17 \times 10^{-5} = \frac{x^2}{[.222]}$$

$$1.37 \times 10^{-5} = x^2$$

$$3.70 \times 10^{-3} = x$$

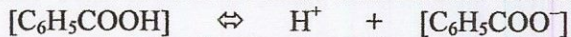
$$3.70 \times 10^{-3} M = [H^+]$$

11) Consider the equilibrium between benzoic acid in its molecular form and its ionic form  
 $C_6H_5COOH \rightleftharpoons H^+ + C_6H_5COO^-$

And answer the following. If HCl (aq) acid is added which way would the equilibrium shift after the  $H^+$  was added?  left  right  no change

12) If NaOH (aq) is added then which way would the equilibrium shift after the  $OH^-$  is added and  $H^+$  removed?  left  right  no change

13) A buffer solution could be made with benzoic acid and benzoate



and since you know that the Ka value of benzoic acid is  $6.17 \times 10^{-5}$  then a solution made with 0.300 M  $[C_6H_5COOH]$  and 0.500 M  $[C_6H_5COO^-]$  concentrations would give what  $[H^+]$  concentration?

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

$$3.70 \times 10^{-5} = [H^+]$$

$$6.17 \times 10^{-5} = \frac{[H^+][.500 + x]}{[.300 - x]}$$

but x small so ignore

$$6.17 \times 10^{-5} = \frac{[H^+][.500]}{[.300]}$$

would give a buffer at pH = 4.43

14) If the concentration of  $[OH^-] = 3.45 \times 10^{-5}$  then the pH of this solution is

3.45    4.46    9.00     9.54    10.55

$$[OH^-][H^+] = 1 \times 10^{-14}$$

$$[3.45 \times 10^{-5}][H^+] = 1 \times 10^{-14}$$

$$[H^+] = 2.90 \times 10^{-10}$$

$$pH = -\log [H^+] = -\log (2.90 \times 10^{-10})$$

$$pH = 9.54$$

15) Which of the following is the strongest acid if placed in a solvent that can distinguish among strong acids in water

HF      HCl      HBr      **HI**

EN →  
↓ size I<sup>-</sup> largest  
most O atoms

16) Which of these is the strongest acid in water

HClO      HClO<sub>2</sub>      HClO<sub>3</sub>      **HClO<sub>4</sub>**

17) Complete the K<sub>sp</sub> expression for lead (II) bromide PbBr<sub>2</sub>

$$K_{sp} = [Pb^{2+}][Br^{-}]^2$$

18) The K<sub>sp</sub> value for lead (II) bromide is found to be  $2.1 \times 10^{-6}$ . The ion product for a particular solution of lead (II) bromide is found to be  $3.33 \times 10^{-5}$  so therefore there will be **precipitate will form** gas will be given off

$$IP > K_{sp}$$

19) If the K<sub>sp</sub> =  $7.9 \times 10^{-16}$  for iron(II) hydroxide Fe(OH)<sub>2</sub> then in a saturated solution of Fe(OH)<sub>2</sub> the concentration of Fe<sup>2+</sup> ions will be [Fe<sup>2+</sup>]=

$$7.9 \times 10^{-16} = [Fe^{2+}][OH^{-}]^2$$

$$7.9 \times 10^{-16} = [x][2x]^2$$

$$7.9 \times 10^{-16} = 4x^3$$

$$1.98 \times 10^{-16} = x^3$$

$$5.8 \times 10^{-6} = x = [Fe^{2+}]$$

20) If the K<sub>sp</sub> =  $7.9 \times 10^{-16}$  for iron(II) hydroxide Fe(OH)<sub>2</sub> then in a saturated solution of Fe(OH)<sub>2</sub> the pH value will be

so from above

$$[OH^{-}] = 2x = 2(5.8 \times 10^{-6})$$

$$[OH^{-}] = 1.16 \times 10^{-5}$$

$$[H^{+}] = \frac{1 \times 10^{-14}}{1.16 \times 10^{-5}}$$

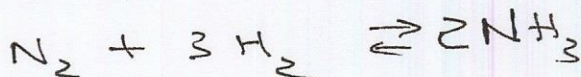
$$[H^{+}] = 8.6 \times 10^{-10}$$

$$pH = -\log[H^{+}] = 9.07$$

21) The following is a plot of the titration of **benzoic acid** or hydrochloric acid



22) If  $K_p = (P_{NH_3}^2) / (P_{N_2} P_{H_2}^3)$  then write the balanced equation that is the basis for this equilibrium constant expression.



synthesis of ammonia