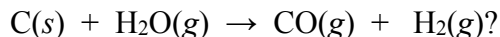Name _____

CH302H   **EXAM 2**   Spring 2013

**Multiple Choice** Neatly write your choice in the blank provided. (3 pts each)

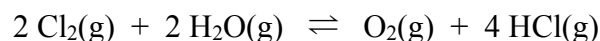_____ 1.  What is the effect of a volume decrease on the reaction:

$$C(s) + H_2O(g) \rightarrow CO(g) + H_2(g)?$$

(a) $K$ increases       (c) more $H_2O(g)$ and $C(s)$ are produced       (d) no change

(b) $K$ decreases       (d) more $CO(g)$ and $H_2(g)$ are produced

_____ 2.  A group who investigated the formation of ammonia from its elements determined that $K_c$ is 90 at 773 K and 3 at 873 K. Is this reaction endothermic or exothermic?

(a) Endothermic.

(b) Neither; the reaction is at equilibrium.

(c) Exothermic

(d) Cannot tell; insufficient information is given.

_____ 3.  Given the following equilibrium data at 973 K:

$$MgCl_2(s) + 1/2\ O_2(g) \rightleftharpoons MgO(s) + Cl_2(g) \qquad K_p = 2.95$$

$$MgCl2(s) + H2O(g) \rightleftharpoons MgO(s) + 2\ HCl(g) \qquad K_p = 8.40$$

Calculate the equilibrium constant Kp at 973 K for

$$2\ Cl_2(g) + 2\ H_2O(g) \rightleftharpoons O_2(g) + 4\ HCl(g)$$

(a) 5.50          (b) 11.4          (c) 8.11          (d) 2.85          (e) 24.8

_____ 4.  Which of the following acids is not a strong acid?

(a) $HClO_4$          (b) $H_2SO_4$          (c) $HNO_3$          (d) $H_3PO_4$          (e) $HCl$

_____ 5.  The ion product constant $K_w$ for water is $1.14 \times 10^{-15}$ at 0°C.
What is the pH of neutral water at 0°C?

(a) 6.15          (b) 6.58          (c) 7.00          (d) 7.47          (e) 7.94

_____ 6.  At 25°C, $K_p = 6.9 \times 10^{-5}$ for the reaction:
$$N_2(g) + 3\ H_2(g) \rightarrow 2\ NH_3(g).$$

Calculate $K_c$ at 25°C for this reaction.

(a) $2.8 \times 10^4$     (b) $6.8 \times 10^5$     (c) $4.1 \times 10^8$     (d) $1.7 \times 10^7$     (e) $1.1 \times 10^3$

_____ 7.  What is the pH of a buffer solution that is 0.20 M in HCN and 0.12 M in NaCN? $K_a = 6.2 \times 10^{-10}$.

(a) 9.09          (b) 9.53          (c) 10.01          (d) 9.31          (e) 4.79

_____  **8.** A 100 mL sample of 0.2 m $NH_3$ solution is titrated to the equivalence point with 50 mL of 0.4 M HCl. What is the final $[H_3O^+]$? The ionization constant of $NH_3$ is $1.8 \times 10^{-5}$.

(a) $1.00 \times 10^{-7}$ M          (c) $6.09 \times 10^{-6}$          (e) $5.05 \times 10^{-7}$ M

(b) $8.61 \times 10^{-6}$ M          (d) $3.7 \times 10^{-7}$ M

_____  **9.** Josh made a phosphate buffer by mixing 0.55 mol $KH_2PO_4$ and 0.55 mol $K_2HPO_4$ into a liter of solution. To this 1 L buffer solution he added 0.25 mol of KOH. What is the resulting pH after this addition? For $H_3PO_4$, $pK_{a1} = 2.12$, $pK_{a2} = 7.21$, and $pK_{a3} = 12.68$.

(a) 7.64          (b) 6.78          (c) 7.37          (d) 7.21          (e) 6.24

_____  **10.** What is the pH of a 0.1 M solution of sodium acetate? You should know this $K_a$ or find what you need on another question.

(a) 5.13          (b) 7.48          (c) 9.13          (d) 8.87          (e) 9.01

# True or False   For each of the following statements write "T" for true, or "F" for false in the blanks provided. (2 pts each)

_____  **11.** Both the equilibrium equation and the value of the equilibrium constant depend on how the chemical equation is written and balanced.

_____  **12.** The concentration of $NO_2$ will decrease when the equilibrium of the reaction:

$$NO_2Cl(g) + NO(g) \rightleftharpoons NOCl(g) + NO_2(g)$$

is disturbed by adding $NO_2Cl$.

_____  **13.** Neutral pH is always 7.

_____  **14.** A mixture of a weak acid with a salt of its conjugate base is an acidic buffer.

_____  **15.** Indicators may be used to monitor the acid/base character of solutions because  the structures of the indicators absorb different types of photons as a function of pH.

_____  **16.** Mixing 100 mL of 0.1 M HF with 50 mL of 0.2 M NaOH will make a solution with a pH = 7 at 25°C.

_____  **17.** A buffered solution of acetic acid ($pK_a = 4.75$) and sodium acetate with a pH = 3 has more acetate ion than acetic acid.

_____  **18.** You can make a buffer solution with HF and HCl.

_____  **19.** The pH of a solution made by mixing 100 mL of 0.2 M acetic acid with 50 mL of 0.2 M NaOH is 4.75.

_____  **20.** The pH of a 1 M solution of an acid with a $pK_a = 4$ is lower than for a 1 M solution of a base with a $pK_b = 5$.

21. Gases A and B will react slowly to form C by the following reaction:

$$A + B \rightleftharpoons C$$

The tank shown has 0 psi to start with. Then, gas A is added to the tank until the pressure gauge reads 29.4 psi. Then gas B is added until the pressure reads 58.8 psi. Then the tank is sealed and put aside for 48 hours to allow A and B to react. After the reaction had equilibrated, the pressure gauge shows 44.1 psi. What is the value of $K_p$ for this reaction? (5 pts -- a friendly reminder that 14.7 psi = 1atm)
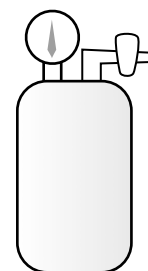
22. Consider the following gas phase reaction at 100°C:      $X_2O_4 (g) \rightleftharpoons 2 XO_2 (g)$

0.75 moles of $X_2O_4$ is injected into an empty 1.00 L container at this temperature and the reaction then proceeds to equilibrium. At equilibrium, there are 0.60 moles of $X_2O_4$. What is $K_p$ for this reaction at this temperature? I repeat, what is $\underline{K_p}$ ?  (5 pts.)

**23.** You have 500 mL of a 0.05 M HF solution. How many grams of NaF should you add to make a solution buffered at a pH of 3.5? You can ignore the volume change from the addition of the solid. $K_a = 6.3 \times 10^{-4}$. (5 pts.)

**24.** Sulfuric acid, $H_2SO_4$ is a polyprotic acid. The first $K_a$ is greater than 100, which is why sulfuric acid is a strong acid. The second $K_a = 1.2 \times 10^{-2}$. What is the concentration of sulfate ion, $SO_4^{2-}$ in a 0.085 M solution of sulfuric acid? (5 pts.)

**25.**   A 50.0 mL sample of a mixture of HCl and $H_3PO_4$ was titrated with 0.200 M NaOH. The first equivalence point was reached after 100.0 mL of base, and the second equivalence point was reached after 125 mL of base.   For $H_3PO_4$:  $pK_{a1} = 2.12$       $pK_{a2} = 7.21$       $pK_{a3} = 12.68$

   **(a)** What is the concentration of $H_3O^+$ at the first equivalence point? (3 pts.)

   **(b)** What are the initial concentrations of HCl and $H_3PO_4$ in the mixture? (3 pts.)

   **(c)** What percent of the HCl is neutralized at the first equivalence point? (3 pts.)

   **(d)** What is the pH of the mixture before addition of any base? (3 pts.)

   **(e)** Sketch the pH titration curve, and label the buffer regions and equivalence points. (3 pts.)

**26.**   Benzoic acid ($C_6H_5COOH$) has a $K_a = 6.46 \times 10^{-5}$. It's conjugate base is the benzoate anion ($C_6H_5COO^-$). A buffer is made by mixing 200 mL of 0.2 M benzoic acid solution with 200 mL of a 0.5 M solution of sodium benzoate.

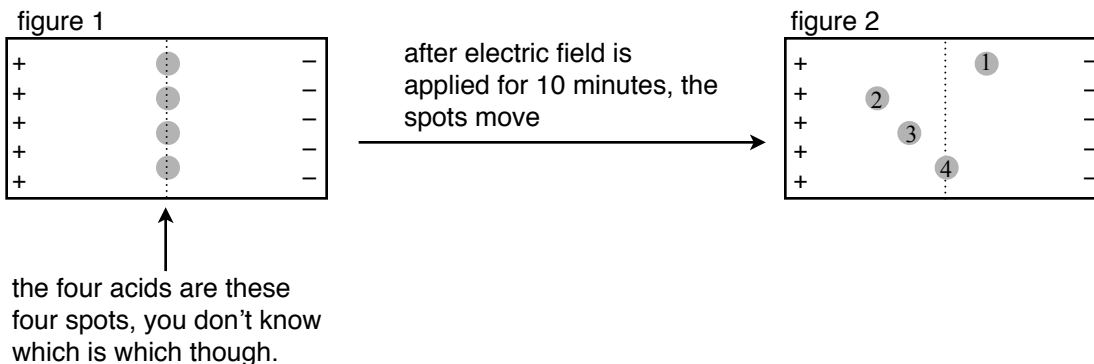   **(a)** What is the pH of the resulting buffer? (3 pts.)

   **(b)** What is the pH of the solution if you mix in 100 mL of 0.2 M HCl? (3 pts.)

**27.** Four Species: 2 monoprotic acids = HA and HC, one diprotic acid $H_2X$, and one base B.

The Data: HA: $K_a = 1.0 \times 10^{-5}$  HC: $K_a = 1.0 \times 10^{-9}$  B: $K_b = 1.0 \times 10^{-5}$

$H_2X$: $K_{a1} = 1.0 \times 10^{-2}$  $K_{a2} = 1.0 \times 10^{-4}$

Each of these species is fluorescent and are easily seen when a black light is shined on paper that has been blotted with a solution of these acids (their conjugates fluoresce equally well). The experiment is to have 4 test tubes containing a tiny amount of each acid (say 10-15 mg). Then a little buffer of pH=7.00 is added to each test tube and each of the species dissolve completely. The buffer, being a buffer, remains pretty much at a pH of 7.00. Next, 3 drops from each test tube are spotted on a piece of porous chromatography paper (think filter paper but nicer). All the spots are in a line in the center of the paper (see figure 1). Then the paper is soaked in the pH 7.00 buffer (same as previously mentioned) and an electric field is applied to the ends: one is is very positive (+) and the other very negative(-). This causes all ions in the paper to migrate accordingly. This electric field is applied for about 10 minutes and then the paper is removed. A black light is shined on the paper and the 4 spots are visible as seen in figure 2. Your job is to identify which spot is which species. So LABEL each spot in the blanks provided (the spots were numbered 1-4 from top to bottom) and say WHY you picked that acid for that spot. Good luck. (9 pts.)

figure 1

after electric field is applied for 10 minutes, the spots move

figure 2

the four acids are these four spots, you don't know which is which though.

Spot 1 is ——————

Why?

Spot 3 is ——————

Why?

Spot 2 is ——————

Why?

Spot 4 is ——————

Why?