Summer 2012 Exam Two
Chemistry 203

Instructions: There are 25 multiple choice questions each worth 4 points for a total of 100 points. You are required to show evidence of calculations on scratch paper for all numerical problems. You may not leave the room during the exam. PLEASE SILENCE YOUR CELL PHONE! You are required to do your own work - any collaboration is strictly forbidden. Accessing the internet during the exam is strictly forbidden.

I, _____(print your name), have read these instructions and I agree to follow them.

*signature*_____

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1) For the following chemical equilibrium, $K_p = 4.6 \times 10^{-14}$ at 25°C, find the value of K_c for this reaction at 25°C.

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

A) $K_c = 1.9 \times 10^{-15}$ B) $K_c = 2.2 \times 10^{-14}$ C) $K_c = 1.1 \times 10^{-12}$
D) $K_c = 9.4 \times 10^{-14}$ E) $K_c = 4.6 \times 10^{-14}$

2) For the reaction $PCl_5\ (g) \rightleftharpoons PCl_3\ (g) + Cl_2\ (g)$ $K_c = 0.0454$ at 261°C. If a vessel is filled with these gases such that the initial concentrations are $[PCl_5] = 0.2$ M, $[PCl_3] = 0.20$ M, and $[Cl_2] = 2.25$ M, in which direction will a reaction occur and why?
A) toward products because $Q = 0.56$ B) toward reactants because $Q = 1.8$
C) toward products because $Q = 2.8$ D) toward reactants because $Q = 0.0454$
E) none of these

3) According to Le Chatelier's Principle:
A) an increase in pressure always causes a change in the position of equilibrium for any reaction
B) the greatest yield of ammonia in the exothermic reaction $N_2 + 3H_2 \rightleftharpoons 2NH_3$ is attained at a high temperature
C) the equilibrium constant is increased for the reaction $A + B \rightleftharpoons C$ if the concentration of A is increased
D) an increase of temperature causes a decrease in the value of the equilibrium constant for an exothermic reaction
E) when an equilibrium system is stressed, the system reacts to offset the stress

4) Equilibrium constant *K* is constant except when one varies the:
A) concentrations of the reactants B) temperature of the reaction
C) concentration of the products D) partial pressures of the reactants
E) *K* always remains constant

5) Consider the following reaction at a certain temperature.
$2SO_3(g) \rightleftharpoons 2SO_2(g) + O_2(g)$
When the initial concentration of $SO_3(g)$ is 0.128 M, the concentration of oxygen gas at equilibrium is found to be 0.0130 M. Calculate K_c for this reaction.
A) 8.45×10^{-4} B) 1.62×10^{-2} C) 7.64×10^{-5} D) 1.47×10^{-3} E) None of these

6)Choose the correct expression for Kp for the reaction: $3\ Fe(s) + 4\ H_2O(g) \rightleftharpoons Fe_3O_4(s) + 4\ H_2(g)$

A) $\dfrac{P(H_2)}{P(H_2O)}$ B) $\dfrac{[Fe_3O_4]\,P(H_2)}{[Fe]\,P(H_2O)}$ C) $\dfrac{[Fe_3O_4][H_2]^4}{[Fe][H_2O]^4}$

D) $\dfrac{[Fe_3O_4][H_2]}{[Fe][H_2O]}$ E) $\dfrac{P(H_2)^4}{P(H_2O)^4}$

7) A solution has pOH of -0.47 under standard conditions. This means that:

A) the solution has a pH of 13.53
B) the solution has an $[OH^-] = 0.34$ M
C) the solution has an $[OH^-]$ greater than 10.0 M
D) the solution has an $[OH^-] = 2.95$ M
E) The solution has an $[H^+] = 2.95$ M

8) 0.272 g of a monoprotic acid (Mw = 189 g/mol) is dissolved in water to produce 25.0 mL of a solution with pH = 4.93. Determine the ionization constant of the acid.

A) 4.1×10^{-8}
B) 1.4×10^{-10}
C) 2.1×10^{-4}
D) 2.8×10^{-7}
E) 2.4×10^{-9}

9) Determine the pH of 263 ml of solution which has $[NH_4I] = 0.300$ M. $K_b = 1.74 \times 10^{-5}$ for NH_3(aq).

A) 2.6 B) 11.4 C) 4.9 D) 9.1 E) 4.6

10) What is the pH of a 0.250 M solution of formic acid? $K_a = 1.8 \times 10^{-4}$

A) 11.8 B) 2.2 C) 0.60 D) 5.4 E) 8.6

11) Which among the following pairs is inefficient as buffer pair?

A) ammonium chloride and ammonium hydroxide
B) sodium chloride and sodium hydroxide
C) boric acid and sodium borate
D) potassium carbonate and potassium bicarbonate
E) potassium fluoride and hydrofluoric acid

12) What is the buffer range (2.0 pH units) for a benzoic acid/sodium benzoate buffer? [*K*a for benzoic acid is 6.3×10^{-5}]

A) 8.8 - 10.8 B) 7.4 - 9.4 C) 5.3 - 7.3 D) 4.7 - 6.7 E) 3.2 - 5.2

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Data for question 13:

methyl orange: red at pH < 3.1: orange at pH 3.1-4.4: yellow-orange above pH 4.4
litmus: red at pH < 4.5: purple at pH 4.5-8.3: blue above pH 8.3
thymol blue: yellow at pH < 8.0: green at pH 8.0-9.6: blue above pH 9.6
trinitrobenzene: colorless at pH < 12: yellow at pH 12.0-1: orange above pH 14.0

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13) Which of the pH indicators from the list above would be most appropriate for the titration of 0.30 M acetic acid ($K_a = 1.8 \times 10^{-5}$) with 0.15 M sodium hydroxide?

A) methyl orange B) litmus C) thymol blue D) trinitrobenzene
E) Both thymol blue and litmus can be used.

14) Determine the $[F^-]$ of the following solution. Initial concentrations are given.

[HF] = 1.296 M, [NaF] = 1.045 M, K_a for HF is 6.6×10^{-4}

A) 1.046 M B) 2.344 M C) 5.3×10^{-4} M D) 8.2×10^{-4} M E) 0.251 M

15) If some NH_4Cl is added to an aqueous solution of NH_3:

A) the pH of the solution will increase
B) the pH of the solution will decrease
C) the solution will not have pH
D) the pH of the solution will not change
E) NH_4Cl cannot be added to NH_3

16) The molar solubility of $SrSO_4$ ($K_{sp} = 7.6 \times 10^{-7}$) is:

A) 2.8×10^{-5} M B) 7.6×10^{-7} M C) 8.7×10^{-8} M D) 8.7×10^{-4} M E) 9.1×10^{-3} M

17) The solubility of a salt MX_2 with a molar mass of 114 g/mole is 3.42 g/liter. Calculate the K_{sp}.

A) 2.70×10^{-5} B) 1.08×10^{-4} C) 9.00×10^{-4} D) 2.25×10^{-4} E) 6.75×10^{-8}

18) A solution contains $[Ba^{2+}] = 5.0 \times 10^{-5}$ M, $[Ag^{+}] = 3.0 \times 10^{-5}$ M, and $[Zn^{2+}] = 2.0 \times 10^{-7}$ M. Sodium oxalate is slowly added so that $[C_2O_4^{2-}]$ increases.

Salt	BaC_2O_4	ZnC_2O_4	$Ag_2C_2O_4$
K_{sp}	1.5×10^{-8}	1.35×10^{-9}	1.1×10^{-11}

What is the concentration of the first cation to precipitate when the second cation just begins to precipitate?

A) 1.3×10^{-6} B) 2.2×10^{-6} C) 5.0×10^{-5} D) 1.35×10^{-9} E) 1.1×10^{-11}

19) Which of the following salts, each of which has a solubility product equal to 1.0×10^{-6}, has the greatest molar solubility?

A) MX B) MX_2 C) MX_3 D) M_2X E) They are all the same

20) A homeowner in Boston becomes concerned that there may be appreciable amounts of lead in her drinking water due to 150-year old water pipes in her house. Consequently, she takes a sample of her drinking water in to be analyzed. The laboratory technician, who is new on the job, has been told to analyze by precipitating the lead ion as the iodide ($K_{sp} = 7.1 \times 10^{-9}$ for PbI_2) by slowly adding small portions of 1.00 M NaI solution.

If we assume that the concentration of lead in the solution is 1.00 mg/liter or approximately 4.8×10^{-6} M (this would be 1.0 part per million) is it possible to detect the lead in the drinking water by adding a total of no more than 10.0 mL of NaI solution to a 100 mL sample of drinking water? You must of course consider dilution effects. What is *Q*?

A) yes, $Q = 4.0 \times 10^{-7}$ B) yes, $Q = 3.6 \times 10^{-8}$
C) no, $Q = 1.6 \times 10^{-13}$ D) no, $Q = 3.6 \times 10^{-8}$
E) no, $Q = 4.0 \times 10^{-7}$

21. Calculate the solubility of magnesium sulfate, $MgSO_4$, when placed into a 0.10 M $MgCl_2$ solution. K_{sp} for $MgSO_4 = 5.9 \times 10^{-3}$

A. 4.2×10^{-2} M B. 5.9×10^{-2} M C. 7.7×10^{-2} M D. 3.5×10^{-5} M E. 3.5×10^{-6} M

22) For the reaction $2\ NO(g) \rightleftharpoons N_2O_4(g)$ K_p equals _____.

A) K_c B) RT/K_c C) $K_c(RT)$ D) K_c/RT E) $K_c(RT)^2$

23) The following compounds are available as 0.10 M aqueous solutions: pyridine ($pK_b = 8.82$), triethylamine ($pK_b = 3.25$), $HClO_4$, NaOH, phenol ($pK_a = 9.96$), HClO ($pK_a = 7.54$), and NH_3 ($pK_b = 4.74$). Identify two solutions that could be used to prepare a buffer with a pH of approximately 5.

A) pyridine and $HClO_4$ B) triethyamine and $HClO_4$ C) phenol and NaOH
D) HClO and NaOH E) None of these will work

24) How will addition of sodium chloride affect the pH of a HCl solution?

A) It will lower the pH. B) The pH will not change. C) The solution becomes hotter.
D) The pH cannot be measured. E) It will raise the pH.

25) Consider the reaction:

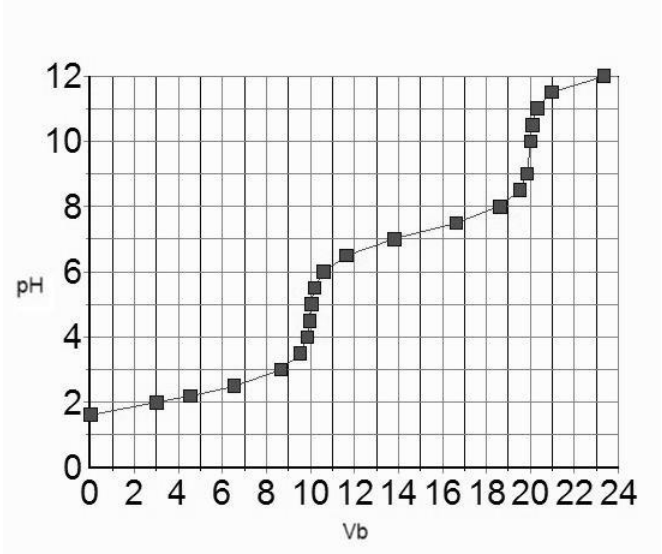
$$HC_2H_3O_2 + H_2O \rightleftharpoons H_3O^{+} + C_2H_3O_2^{-}$$

Choose the pair of substances that are both bases in the reaction.

A) $HC_2H_3O_2$ and H_3O^{+} B) H_2O and $C_2H_3O_2^{-}$ C) H_2O and H_3O^{+}
D) $HC_2H_3O_2$ and $C_2H_3O_2^{-}$ E) H_3O^{+} and $HC_2H_3O_2$

Bonus:

The titration curve for 10.0 mL of 0.100 M H_3PO_4(aq) with 0.100 M NaOH(aq) is given below.



Estimate the pK_{a2} of H_3PO_4.