Chemistry 10123, **Exam 2** Name: _____
February 20, 2019 (Please Print)

1. (9 points) **SHOW ALL WORK.** At 50 °C, the ion product (K_W) for water is 5.48 x 10^{-14}. Determine the pH of a 0.0025 M $Ba(OH)_2$ solution at this temperature. Include a ***balanced chemical equation*** for the relevant ***equilibrium reaction***.

2. (2 points) Among the following, circle the ***strongest acid***.

   $HBrO_3$ $HClO_2$ H_2SO_3 $HBrO_2$ $HClO_3$ H_2SeO_3

3. (2 points) Among the following, circle the ***weakest acid***.

   H_2Se HBr HF H_2O H_2S HCl

4. (9 points) **SHOW ALL WORK.** At 100 °C, a reaction has an activation energy (E_a) of 165 kJ/mole. When a catalyst is added (at the same temperature), the reaction rate increases by a factor of 10 billion (i.e., 1.00 x 10^{10} times faster). Determine the activation energy of the catalyzed reaction.

5. (4 points) (a) The conjugate acid of $HAsO_4^{2-}$ is _____.
   (b) The conjugate base of HSF_3 is _____.

6. (2 points) A molecule or ion that can function as both an acid and a base is described as being _____. An excellent example of such a species is _____.

7. (4 points) Which one of the following molecules or ions behaves as a ***weak base*** *in aqueous solution*? Circle your answer and then write a balanced chemical equation for this process.

   HN_3 NH_4^+ N_2O_5 NO_2^- OH^- N_2

8. (10 points) Consider the following reaction in terms of the Lewis Acid-Base concept. Write ***complete Lewis electron dot formulas*** for all reactants and products. ***Clearly indicate which reactant is the Lewis acid and which is the Lewis base***. Use arrows to illustrate the formation and breaking of any bonds as the reaction proceeds from left to right.

$$SBr_2 \quad + \quad BrOCN \quad \longrightarrow \quad SBr_3^+ \quad + \quad OCN^-$$

9. (8 points) For two solutions, **A** and **B**, fill in the missing values (at 25 °C) in the table below. *Pay attention to significant figures*.

Solution	**pH**	**$[H_3O^+]$**	**pOH**	**$[OH^-]$**
A	**- 1.04**			
B			**3.275**	

10. (10 points) **SHOW ALL WORK.** As the TA for a Gen Chem lab, you are required to prepare 50.0 L of aqueous HBr with a pH of 2.50. In the chemistry storeroom, you find a bottle of stock solution that is 48.0 % HBr by weight and has a density of 1.50 g/mL. Determine the volume (in mL) of stock solution that you will need in order to prepare 50.0 L of HBr solution with pH = 2.50.
(molar mass: HBr = 80.9, H_2O = 18.0)

11. Consider the following gas-phase reaction for which $K_c = 8.30 \times 10^5$ at 500 °C.

$$CS_{2(g)} + 4\,H_{2(g)} \rightleftharpoons CH_{4(g)} + 2\,H_2S_{(g)}$$

(a) (4 points) How will the equilibrium amount of $CS_{2(g)}$ be affected by each of following changes? Indicate your answer by writing the appropriate letter.

[**I** = increase, **D** = decrease, **N** = no change]

Change	**moles $CS_{2(g)}$**
add some $CH_{4(g)}$	
add a catalyst	
increase the pressure	
remove some $H_2S_{(g)}$	

(b) (2 points) When the temperature of the above equilibrium system is increased, the value of K_c decreases. This observation indicates that the enthalpy change for the reaction is (circle one):

positive zero negative

(c) (10 points) **SHOW ALL WORK.** At 500 °C, a 2.00 L container was filled with 0.0200 moles of $CS_{2(g)}$ and 0.150 moles of $H_{2(g)}$. Calculate the molar concentration of CS_2 in this system after the above equilibrium is established. ***Clearly state and justify any assumptions that you may make.*** ($K_c = 8.30 \times 10^5$)

12. (4 points) **SHOW ALL WORK.** Consider the following reactions and their equilibrium constants.

$$NO_{(g)} + 1/2\,Br_{2(g)} \rightleftharpoons NOBr_{(g)} \qquad K_p = 7.45$$

$$N_{2(g)} + O_{2(g)} \rightleftharpoons 2\,NO_{(g)} \qquad K_p = 2.85 \times 10^{-21}$$

From this information, determine K_p for the reaction below.

$$2\,NOBr_{(g)} \rightleftharpoons N_{2(g)} + O_{2(g)} + Br_{2(g)}$$

13. (10 points) The following gas-phase reaction is found experimentally to be "first order in H_2 and first order in BrCl." Write the experimental rate law and ***propose*** a reasonable ***two-step mechanism*** for this reaction. ***Briefly explain*** (30 words max) how your mechanism is consistent with the experimental rate law. Clearly indicate which step in your mechanism is the rate-determining step. If your proposed mechanism contains an intermediate, circle it.

$$H_{2(g)} + 2\,BrCl_{(g)} \longrightarrow 2\,HCl_{(g)} + Br_{2(g)}$$

14. (10 points) **SHOW ALL WORK.** At 300 K, the following reaction has $K_c = 1.75 \times 10^{-10}$. At this temperature, 0.75 moles of N_2O_5 and 0.50 moles of NO are combined in a 1.00-L container. Determine the molar concentration of O_2 after equilibrium is achieved.

$$2\,N_2O_{5(g)} \rightleftharpoons 4\,NO_{(g)} + 3\,O_{2(g)}$$