Chemistry 212 Test 2 Name: _____
Spring 2025 (Please print)

Multiple Choice (5 points each, Put answers in CAPS in the left margin.)

1. What is the freezing point of a 0.37 *m* aqueous solution of aluminum chloride ($K_b$ = 1.86 ºC/*m*)?

   A) -0.69 ºC B) -1.38 ºC C) -2.05 ºC D) -2.75 ºC E) -3.44 ºC

2. For the reaction $N_{2\,(g)} + 3\ H_{2\,(g)} \longrightarrow 2\ NH_{3\,(g)}$ which of the following is a valid equation for rate (i.e. rate =)? (recall Δ can be used for *d*, i.e. Δt for *d*t)

   A) $\frac{d[N_2]}{dt}$ C) $3\,\frac{d[H_2]}{dt}$ E) $\frac{1}{2}\frac{d[NH_3]}{dt}$

   B) $-2\,\frac{d[NH_3]}{dt}$ D) $\frac{1}{3}\frac{d[H_2]}{dt}$

3. For the reaction: $CO_{(g)} + Cl_{2\,(g)} \rightleftharpoons COCl_{2\,(g)}$ at equilibrium, some CO is added at constant volume. Which of the following is true for the new equilibrium?

   A) [CO], [$Cl_2$], and [$COCl_2$] all increase.
   B) [CO] and [$Cl_2$] increase and [$COCl_2$] decreases.
   C) [CO] and [$Cl_2$] decrease and [$COCl_2$] increases.
   D) [CO] and [$COCl_2$] increase and [$Cl_2$] decreases.
   E) Cannot determine from the information given.

4. For the following equilibria:

$$C_{(s)} + CO_{2\,(g)} \rightleftharpoons 2\ CO_{(g)} \qquad K_1$$
$$2\ CO_{(s)} + 2\ Cl_{2\,(g)} \rightleftharpoons 2\ COCl_{2\,(g)} \qquad K_2$$
$$C_{(s)} + CO_{2\,(g)} + 2\ Cl_{2\,(g)} \rightleftharpoons 2\ COCl_{2\,(g)} \qquad K_T$$

   A) $K_T = K_1 + K_2$ C) $K_T = K_1 - K_2$ E) $K_T = K_2 - K_1$
   B) $K_T = K_1 \div K_2$ D) $K_T = K_1 K_2$

5. Which of the following statements regarding chemical equilibrium is false?

   A) The concentrations of reactants and products are equal.
   B) The concentrations of reactants and products remain constant.
   C) Reactants are being converted to products and vice versa.
   D) The rates of the forward and reverse reactions are equal.
   E) Two of the statements (A-D) are false.

6. For the equilibrium $H_{2\,(g)} + I_{2\,(g)} \rightleftharpoons 2\ HI_{(g)}$ which of the following would result in a shift of the equilibrium to the right?

   A) Increasing pressure C) Adding HI E) Adding NaOH
   B) Adding a catalyst D) Decreasing pressure

7. For the reaction: $HOCl + C_5H_5N \longrightarrow C_5H_5NH^+ + OCl^-$ (all species aqueous), which is the conjugate base to HOCl?

A) HOCl B) $C_5H_5N$ C) $C_5H_5NH^+$ D) $OCl^-$ E) $H_2O$

8. Calculate the $H^+$ ion concentration in $8.8 \times 10^{-4}$ *M* $Ca(OH)_2$.

A) $8.8 \times 10^{-4}$ *M*
B) $1.8 \times 10^{-3}$ *M*
C) $2.2 \times 10^{-11}$ *M*
D) $1.1 \times 10^{-11}$ *M*
E) $5.7 \times 10^{-12}$ *M*

9. Which of the following pairs of reagents constitutes an aqueous buffer system?

A) NaOH, NaCl
B) $Na_2CO_3$, $H_2O$
C) HCl, HOAc
D) $HSO_4^-$, $SO_4^{2-}$
E) $NH_3$, NaOH

Discussion questions (You must show your work to receive credit!)

1. At 273ºC, the reaction, $2\ NO + Br_2 \longrightarrow 2\ NOBr$ (all gases), is observed to exhibit the following dependence of rate on concentration.

| [NO] (M) | [$Br_2$] (M) | rate ($Ms^{-1}$) |
|---|---|---|
| 0.10 | 0.10 | 12 |
| 0.25 | 0.10 | 75 |
| 0.10 | 0.25 | 30 |

a) What is the rate law for this reaction?
b) What is the rate constant for this reaction? (10 points)

2. Explain your answer to Multiple Choice question #3. (6 points)

3. Consider an equilibrium whose forward reaction is exothermic. Which way will the equilibrium shift if the reaction is heated? Provide a physical explanation for your prediction. (7 points)

4. Phosphorus pentachloride decomposes according to the chemical equation

   $PCl_{5\,(g)} \rightleftharpoons PCl_{3\,(g)} + Cl_{2\,(g)}$ $K_c = 1.80$ at 250 ºC

   A 0.1757 mol sample of $PCl_5$ is injected into an empty 2.30 L reaction vessel held at 250 ºC. Calculate the concentrations of $PCl_5$ and $PCl_3$ at equilibrium. (10 points)

5. What is the pH of a (12 points)
   a) 0.162 *M* HBrO ($K_a = 2.0 \times 10^{-9}$)

   b) 0.100 *M* NaOCl ($K_a$(HClO) $= 3.0 \times 10^{-8}$)?

6. Explain your answer to Multiple Choice question #8. (6 points)

7. Which is the stronger acid in non-aqueous solution and why: HBr or HCl? (In water, the two acids are equally strong, but in some other solvents one would be stronger.) (5 points)