Chemistry 212 Test 3 Name:_____
Spring 2025

Multiple Choice (5 points each, Put answers in CAPS in the left margin.)
R = 8.314 J/mol•K = 0.0821 L•atm/mol•K

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

A) KOH, KCl
B) $H_2PO_4^-$, $HPO_4^{2-}$
C) HCl, $H_3PO_4$
D) $H_2CO_3$, $H_2O$
E) $NH_3$, HCl

2. For the following equilibria (examine the 3 reactions carefully):

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

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

3. Which of the following is the best example of a Lewis base that is **not also** a Brønsted-Lowry base?

A) $Ag^+$ B) $CH_4$ C) $CO_3^{2-}$ D) $Cl^-$ E) $NH_3$

4. Addition of which of the following would have no effect on the solubility of AgCN?

A) HCl B) NaCN C) $AgNO_3$ D) $NaNO_3$ E) $HClO_4$

5. Which of the following complex ions is most stable in aqueous solution?

A) $CdI_4^{2-}$ $K_f = 2.0 \times 10^6$
B) $Cu(CN)_4^{2-}$ $K_f = 1.0 \times 10^{25}$
C) $Cu(NH_3)_4^{2+}$ $K_f = 5.0 \times 10^{13}$
D) $HgCl_4^{2-}$ $K_f = 1.7 \times 10^{16}$
E) $Hg(CN)_4^{2-}$ $K_f = 2.5 \times 10^{41}$

6. Which of the following processes is entropically unfavorable (for the system)?

A) Scattering seeds in the wind.
B) Boiling water.
C) Expanding a gas into a vacuum.
D) The burning of coal.
E) Making a hard-boiled egg.

7. The small bags of silica gel you often see in a new shoe box are placed there to control humidity. Despite its name, silica gel is a solid. It is a chemically inert, highly porous, amorphous form of $SiO_2$. Water vapor readily adsorbs onto the surface of silica gel, so it acts as a desiccant.

A) $\Delta G < 0, \Delta H < 0, \Delta S < 0$
B) $\Delta G < 0, \Delta H > 0, \Delta S < 0$
C) $\Delta G < 0, \Delta H < 0, \Delta S > 0$
D) $\Delta G > 0, \Delta H > 0, \Delta S > 0$
E) $\Delta G > 0, \Delta H < 0, \Delta S < 0$

8. Which of the following is a statement of the second law of thermodymanics?

   A) When reactants are converted into products, the change in enthalpy is independent of the number of steps taken.
   B) The entropy of a perfect crystal of any substance at absolute zero is zero.
   C) Energy can be converted from one form to another but cannot be created or destroyed.
   D) State functions are properties that are determined by the state the system is in.
   E) The entropy of the universe is always increasing.

9. Which of the following reactions shows a decrease in entropy?

   A) $H_{2\,(g)} + Cl_{2\,(g)} \rightarrow 2\ HCl_{(g)}$
   B) $BaO_{(s)} + CO_{2\,(g)} \rightarrow BaCO_{3\,(s)}$
   C) $SiCl_{4\,(\ell)} + 2\ H_2O_{(l)} \rightarrow SiO_{2\,(s)} + 4\ HCl_{(aq)}$
   D) $2\ CH_3OH_{(\ell)} + 3\ O_{2\,(g)} \rightarrow 2\ CO_{2\,(g)} + 3\ H_2O_{(g)}$
   E) $2\ SO_{3\,(g)} \rightarrow 2\ SO_{2\,(g)} + O_{2\,(g)}$

Discussion Questions: (You must show your work to receive credit.)

1. What is the pH of a_____ solution
   a) 0.562 *M* HBrO ($K_a = 2.0 \times 10^{-9}$)

   b) 1.20 *M* NaOCl ($K_a$(HClO) = $3.0 \times 10^{-8}$)? (10 points)

2. When Lewis acids and bases interact, a coordinate covalent bond typically forms. How is it different from a "normal" covalent bond? Functionally, how is a coordinate covalent bond different from a "normal" covalent bond? (i.e. What effect(s) arise in the CCB, not in a NCB)?) (6 points)

3. The $K_{sp}$ of $PbBr_2$ is $6.60 \times 10^{-6}$. (i) What is the molar solubility of $PbBr_2$ in pure water? (ii) What is the solubility of $PbBr_2$ in 0.500 M KBr solution? (12 points)

4. For the complex ion $Cu(NH_3)_4^{2+}$ write out the chemical reaction for its formation constant ($K_f$) and the formation constant expression (equation). (6 points)

5. Why is it that increasing the entropy of a system necessarily increases the entropy of the universe. Focus your answer on a system that would result in a decrease in the system entropy. For example, you could use freezing a liquid, crystallization of a salt from solution, etc. (5 points)

6. Consider the equilibrium $N_2O_{4\,(g)} \longrightarrow 2\ NO_{2\,(g)}$. $\Delta G^o = 5.30$ kJ/mol and $\Delta H^o = 57.9$ kJ/mol for this reaction. What are $\Delta S^o$ and $K_p$ for the forward reaction. (T = 25 ºC) At what temperature does the equilibrium shift to the right? Is your answer for $\Delta S^o$ expected or not and why? (16 points)