Unit 7 Test
3/1/2024
50 points total

First and Last Name

Unit 7 Multiple Choice (2.5 points each)

$$H_2O(g) + CO(g) \rightleftharpoons CO_2(g) + H_2(g) \qquad K_P = 136 \text{ at } 500 \text{ K}$$

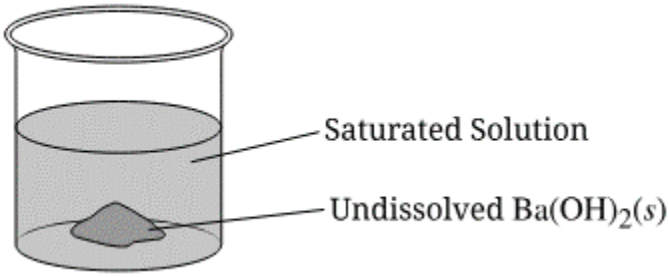
1. A vessel initially contains $H_2O(g)$ at a partial pressure of 0.30 atm, $CO(g)$ at a partial pressure of 0.10 atm, $CO_2(g)$ at a partial pressure of 1.5 atm, and $H_2(g)$ at a partial pressure of 10. atm at 500 K. Which of the following occurs as the system approaches equilibrium at 500 K?

◯ The partial pressures of $H_2O(g)$ and $CO(g)$ increase because $Q > K_P$.

◯ The partial pressures of $H_2O(g)$ and $CO(g)$ increase because $Q < K_P$.

◯ The partial pressures of $CO_2(g)$ and $H_2(g)$ increase because $Q > K_P$.

◯ The partial pressures of $CO_2(g)$ and $H_2(g)$ increase because $Q < K_P$.



2. A student creates a saturated solution of $Ba(OH)_2$, $K_{sp} = 2.6 \times 10^{-4}$, as shown above. Which of the following is true about the $[OH^-]$ in the saturated solution?

◯ The $[OH^-] = [Ba^{2+}]$.

◯ As water evaporates, the $[OH^-]$ does not change.

◯ More $[OH^-]$ will dissolve in a 0.100 M solution of NaOH(aq).

◯ $[OH^-] = 0$ M since there is solid on the bottom of the beaker.

$$NO(g) + CO_2(g) \rightleftharpoons NO_2(g) + CO(g)$$

3. Which of the following changes will increase the amount of $NO_2(g)$ in the equilibrium system represented by the equation above?

- ◯ Removing CO(g) from the system
- ◯ Removing $CO_2(g)$ from the system
- ◯ Increasing the volume of the reaction vessel
- ◯ Decreasing the volume of the reaction vessel

4. The value of K_{sp} for the salt Ag_2CrO_4 is 8.00×10^{-12}. The $[Ag^+]$ in a saturated solution of Ag_2CrO_4 is approximately

- ◯ 6.3×10^{-8}
- ◯ 2.8×10^{-6}
- ◯ 1.3×10^{-4}
- ◯ 2.5×10^{-4}

Compound	$[X^+]$ in Saturated Solution
BaX_2	1.60×10^{-4} M
PbX_2	3.90×10^{-8} M
CdX_2	2.45×10^{-12} M
CrX_2	4.69×10^{-7} M

5. Based on $[X^+]$ in saturated solutions of the compounds listed in the table above, which of the following compounds has the smallest K_{sp} value?

- ◯ BaX_2
- ◯ PbX_2
- ◯ CdX_2
- ◯ CrX_2

6. A student places excess $CaSO_4(s)$ in a beaker containing 100 mL of water and places excess $PbSO_4(s)$ in another beaker containing 100 mL of water. The student stirs the contents of the beakers and then measures the electrical conductivity of the solution in each beaker. The student observes that the conductivity of the solution in the beaker containing the $CaSO_4(s)$ is higher than the conductivity of the solution in the beaker containing the $PbSO_4(s)$. Which of the following explains why?

- $CaSO_4(s)$ and $PbSO_4(s)$ both contain one cation and one anion.
- The molar mass of $CaSO_4$ is less than the molar mass of $PbSO_4$.
- $CaSO_4(s)$ is more soluble in water than $PbSO_4(s)$.
- Ca^{2+} is more conductive than Pb^{2+}.

7. A student creates a saturated solution of NaCl(aq). Which of the solutions below would cause NaCl(s) to precipitate?

- HCl (aq)
- $Cu(NO_3)_2$ (aq)
- H_2O_2 (aq)
- $C_6H_{12}O_6$ (aq)

8. Equimolar amounts of NO(g) and O_2(g) are injected into an evacuated, rigid container, where they react according to the equation below.

$$2\ NO(g) + O_2(g) \rightleftharpoons 2\ NO_2(g) \qquad \Delta H = -112\ kJ/mol_{rxn}$$

The partial pressures of the gases in the container are monitored at constant temperature and recorded in the table below.

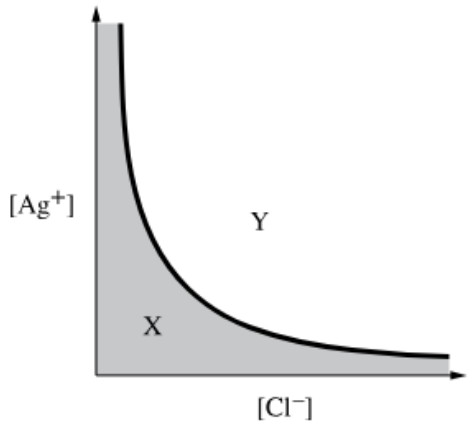
Time	P_{NO} (atm)	P_{O_2} (atm)	P_{NO_2} (atm)
t_0	1.0	1.0	0.0
t_1	0.80	0.90	0.20
t_2	0.69	0.84	0.31
t_3	0.62	0.81	0.38
t_4	0.58	0.79	0.42
t_5	0.55	0.77	0.45
t_6	0.52	0.76	0.48
t_7	0.50	0.75	0.50
t_8	0.50	0.75	0.50
t_9	0.50	0.75	0.50

Which of the following is true in regards to the rate of the forward reaction and the reverse reaction at time t_3?

- ◯ Only the forward reaction is proceeding at a measurable rate.
- ◯ The rate of the forward reaction is equal to the rate of the reverse reaction.
- ◯ The rate of the forward reaction is less than the rate of the reverse reaction.
- ◯ The rate of the forward reaction is greater than the rate of the reverse reaction.

$$AgCl(s) \rightleftharpoons Ag^{+}(aq) + Cl^{-}(aq)$$

9. The preceding equation represents the equilibrium of a saturated solution of AgCl(aq) in contact with AgCl(s). All points on the curve in the graph represents values of $[Ag^{+}]$ and $[Cl^{-}]$ for which the product $[Ag^{+}]\,[Cl^{-}]$ is equal to the value of K_{sp} for AgCl. Which of the following provides the correct comparison of Q and K_{sp} and describes the net process that occurs at any point in region Y (unshaded) of the graph?



- ◯ $Q > K_{sp}$ and dissolution of AgCl(s) occurs.
- ◯ $Q < K_{sp}$ and dissolution of AgCl(s) occurs.
- ◯ $Q > K_{sp}$ and precipitation of AgCl(s) occurs.
- ◯ $Q < K_{sp}$ and precipitation of AgCl(s) occurs.

$$A^{3+}(aq) + B^{-}(aq) \rightleftharpoons AB^{2+}(aq) \qquad K_{eq} = 240 \text{ at } 25\ ^{\circ}C$$

10. Equal volumes of 0.1 M solutions of A^{3+} (aq) and B^{-} (aq) are mixed and allowed to attain the equilibrium represented above at a temperature of 25 °C. Which of the following statements is correct about the system at equilibrium?

- ◯ $[B^{-}] > [AB^{2+}]$
- ◯ $[B^{-}] < [AB^{2+}]$
- ◯ $[A^{3+}] > [AB^{2+}]$
- ◯ $[A^{3+}] = [AB^{2+}]$

Unit 7 Free Response

For each question, show your work for each part in the space provided after that part. Examples and equations may be included in your responses where appropriate. For calculations, clearly show the method used and the steps involved in arriving at your answers. You must show your work to receive credit for your answer. Pay attention to significant figures.

1. In an experiment, H_2, X_2, and XH_3 gas were placed in an empty, rigid 5.00 L vessel and allowed to reach equilibrium according to the following equation.

$$3\ H_2(g) + X_2(g) \rightleftharpoons 2\ XH_3(g) \qquad \Delta H^o = ???\ kJ/mol_{rxn}$$

   a. Write the expression for the equilibrium constant, K_c, for this reaction.

   b. The experiment begins with initial concentrations of X_2, H_2, and XH_3 as given below. Once the system reaches equilibrium at 298 K the concentration of NH_3 is found to be 0.250 M.

Species	Initial Molarity (mols/L)
H_2	0.200
X_2	0.100
XH_3	0.300

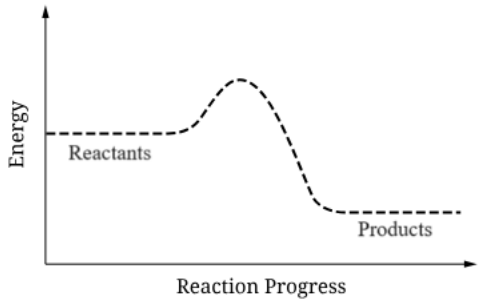
      i. Determine the equilibrium concentration of H_2, in mols/L.

      ii. Determine the value of K_c.

$$3\ H_2(g) + X_2(g) \rightleftharpoons 2\ XH_3(g)$$

c. In a different experiment at 298 K the student begins with 0.200 M concentrations of H_2, X_2, and XH_3. Will the concentration of H_2 at equilibrium be greater than, less than, or equal to 0.200 M? Justify your answer by referring to Q and K_c.

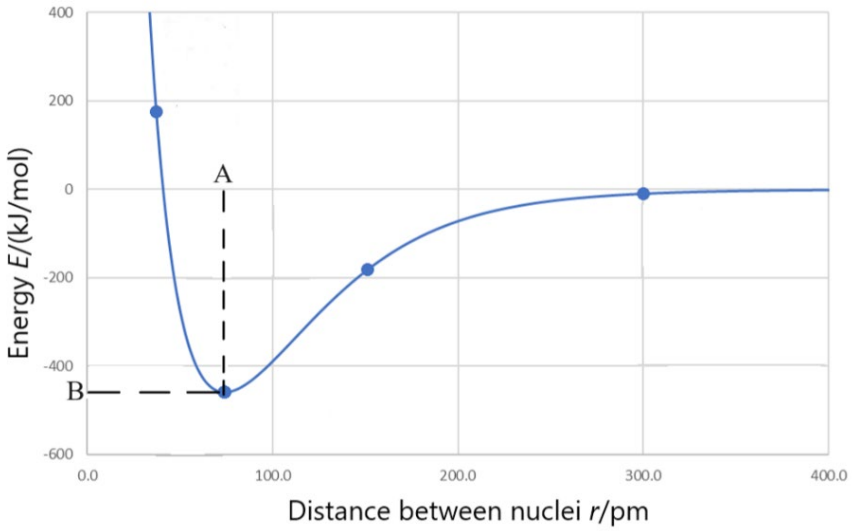
An empty vessel is filled with X_2 and H_2 and allowed to come to equilibrium at 298 K. The reaction profile shown below describes the chemical reaction.



d. Is the reaction exothermic or endothermic? Explain your answer by referring to the reaction profile.

e. The temperature of the equilibrium system is steadily increased to 350. K and again allowed to reach equilibrium. Would the concentration of XH_3 at 350. K be greater than, less than, or the same as the concentration at 298 K?

The figure below shows how the energy changes as the distance between two hydrogen atoms is decreased. At the intersection of points A and B a single bond forms between the two hydrogen atoms to form H−H.



f. Points A and B would be different for a graph that describes a C−C single bond. Choose either point A or point B. Describe how that point would change for C−C single bond. Explain your reasoning.

$$3\ H_2(g) + N_2(g) \rightleftharpoons 2\ NH_3(g)$$

g. In a similar reaction H_2 and N_2 react to form NH_3. A student claims that the reaction between nitrogen and hydrogen to form ammonia, given above, is a redox reaction. Do you agree or disagree with the student? Justify your answer.

2. A student takes a 10. g sample of lead (II) fluoride, $PbF_2(s)$, and mixes it with 100. mL of distilled water to form a saturated solution. The value of K_{sp} for PbF_2 is 3.2×10^{-8} at 298 K.
    a. Write the balanced chemical equation for the change that occurs when solid PbF_2 dissolves in water.

    b. Calculate the concentration of $F^-(aq)$ ions in the saturated solution.

    c. Determine molar solubility, in mols/L, of PbF_2 in the saturated solution.

    d. Would you expect the value you calculated in 2c to increase, decrease, or remain the same if the PbF_2 is dissolved in 100. mL of 0.10 M NaF instead of distilled water? Explain your reasoning.

3. Hydrogen can reduce carbon dioxide to form carbon monoxide at 823 K as shown in the equation below.

$$H_2(g) + CO_2(g) \rightleftharpoons CO(g) + H_2O(g) \qquad K_P = ???$$

a. Calculate the equilibrium constant, K_P, for this reaction given the reactions below that occur at 823 K

Reaction 1	$CoO(s) + H_2(g) \rightleftharpoons Co(s) + H_2O(g)$	$K_{P1} = 0.67$
Reaction 2	$CoO(s) + CO(g) \rightleftharpoons Co(s) + CO_2(g)$	$K_{P2} = 490$

b. Give the equilibrium expression, K_P, for Reaction 1.

c. A student begins Reaction 1 with 25.0 grams of CoO(s) and enough $H_2(g)$ so that the partial pressure is 2.00 atm. Determine the equilibrium partial pressure of $H_2O(g)$ once the system has reached equilibrium. Assume the reaction begins in an evacuated, rigid container.