Read each question carefully before you answer. Work at a steady pace, and you should have ample time to finish. Good Luck!

1. Consider the chemical reaction, $CO(g) + Cl_2(g) \rightleftharpoons COCl_2(g)$; $K = 4.6 \times 10^9\ M^{-1}$.
How do the equilbrium concentrations of the reactants compare to the equilbrium concentration of the product?

__ A. They have to be exactly equal.

__ B. They are much smaller.

__ C. They are much bigger.

__ D. They are about the same.

__ E. You can't tell from the information.

2. For the reaction given below, 2.00 moles of A and 3.00 moles of B are placed in a 6.00 L container.

$$A(g) + 2B(g) \rightleftharpoons C(g)$$

At equlibrium, the concentration of A is 0.300 $mol \cdot L^{-1}$. What is the concentration of B at equilbrium?

__ A. 0.434 $mol \cdot L^{-1}$

__ B. 0.500 $mol \cdot L^{-1}$

__ C. 0.300 $mol \cdot L^{-1}$

__ D. 0.600 $mol \cdot L^{-1}$

__ E. none of these.

3. Consider the reaction from the previous question, $A(g) + 2B(g) \rightleftharpoons C(g)$ [2.00 moles of A and 3.00 moles of B are placed in a 6.00 L container]. At equlibrium, the concentration of A is 0.300 $mol \cdot L^{-1}$. What is the value of K?

__ A. 0.253 M^{-2}

__ B. 0.0.584 M^{-2}

__ C. 0.146 M^{-2}

__ D. 5.309 M^{-2}

__ E. 0.300 M^{-2}

4. Consider the chemical reaction: $H_2(g) + I_2(s) \rightleftharpoons 2HI(g)$; $\Delta H = +68.0\ kJ \cdot mol^{-1}$.
Which of the following statements about the equilbrium is *false*?

__ A. Removing HI(g) as it forms forces the reaction to proceed in the forward direction.

__ B. If the system is heated, the reaction will proceed in the forward direction to eventually attain equilibrium.

__ C. Adding more $I_2(s)$ has no effect on the equlibrium.

__ D. Adding more $H_2(g)$ increases the value of the equilbrium constant.

__ E. If the total pressure on the system is increased by changing the volume, the reaction will proceed in the reverse direction to eventually attain equilibrium.

5. A 10.0 g sample of solid $NH_4Cl(s)$ is heated in a 5.00 L container at 900 °C. At equilibrium the pressure of $NH_3(g)$ is 1.20 atm.

$$NH_4Cl(s) \rightleftharpoons NH_3(g) + HCl(g)$$

The equilibrium constant K_p, for the reaction is:

__ A. 31.0 atm^2

__ B. 1.44 atm^2

__ C. 2.40 atm^2

__ D. 1.20 atm^2

__ E. none of these.

6. At 25 °C, $K_c = 1.58 \times 10^{-8}\ M^3$ for the reaction:

$$NH_4(NH_2CO_2)(s) \rightleftharpoons 2NH_3(g) + CO_2(g)$$

Calculate K_p at 25 °C for this reaction.

__ A. $2.31 \times 10^{-4}\ atm^3$

__ B. $9.45 \times 10^{-6}\ atm^3$

__ C. $2.64 \times 10^{-11}\ atm^3$

__ D. $2.40 \times 10^{-7}\ atm^3$

__ E. $1.09 \times 10^{-12}\ atm^3$

7. Which of the following statements concerning equilibrium is *not* true?

__ A. A system moves spontaneously toward a state of equilbrium.

__ B. A chemical system that is disturbed from an equilbrium condition responds in a manner to restore equlibrium.

__ C. Equilibrium in chemical systems is dynamic, with two opposing processes balancing one another.

__ D. The value of the equlibrium constant for a given chemical reaction mixture is the same regardless of the direction from which the equilibrium is attained.

__ E. The equilibrium constant is independent of temperature.

8. At a certain temperature K for the reaction

$$2NO_2(g) \rightleftharpoons N_2O_4(g)$$

is 7.5 $L \cdot mol^{-1}$. If 2.0 moles of $NO_2(g)$ are placed in a 2.0 L container and permitted to react at this temperature, calculate the concentration of $N_2O_4(g)$ at equilibrium.

__ A. 0.65 M

__ B. 7.5 M

__ C. 0.39 M

__ D. 0.82 M

__ E. none of these.

9. Initially 2.0 moles of $N_2(g)$ and 4.0 moles of $H_2(g)$ were added to a 1.0 L container and the following reaction then occurred:

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

The equilibrium concentration of $NH_3(g)$ = 0.68 $mol \cdot L^{-1}$ at 700 °C. The value for *K* at 700 °C for the formation of $NH_3(g)$ is:

__ A. $3.4 \times 10^{-2}\ L^2 \cdot mol^{-2}$

__ B. $3.1 \times 10^{-3}\ L^2 \cdot mol^{-2}$

__ C. $1.3 \times 10^{-1}\ L^2 \cdot mol^{-2}$

__ D. $1.1 \times 10^{-2}\ L^2 \cdot mol^{-2}$

__ E. none of these.

10. Which of the following equilibrium reactions is *not* affected by changes in pressure?

__ A. $2Hg(l) + O_2(g) \rightleftharpoons 2HgO(s)$

__ B. $4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g)$

__ C. $N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$

__ D. $CuSO_4(s) \rightleftharpoons CuO(s) + SO_3(g)$

__ E. $CO_2(g) + C(s) \rightleftharpoons 2CO(g)$

11. At 699 K, $\Delta G°_{rxn} = -23.25\ kJ \cdot mol^{-1}$ for the reaction $H_2(g) + F_2(g) \rightleftharpoons 2HF(g)$. Calculate the ΔG_{rxn} for this reaction when the partial pressure of $H_2(g)$ and $F_2(g)$ are 10.0 atm each and the partial of HF(g) is 1.00 atm.

__ A. $+36.6\ kJ \cdot mol^{-1}$

__ B. $-50.0\ kJ \cdot mol^{-1}$

__ C. $-36.6\ kJ \cdot mol^{-1}$

__ D. $-3.5\ kJ \cdot mol^{-1}$

__ E. $+3.5\ kJ \cdot mol^{-1}$

12. What is the concentration of H_3O^+ for an aqueous solution with a pH of 8.20?

__ A. 1.0×10^{-14} M

__ B. 1.6×10^{-6} M

__ C. 0.91 M

__ D. 1.4×10^{-3} M

__ E. 6.3×10^{-9} M

13. Consider the following reaction,

$$2NO(g) + O_2(g) \rightleftharpoons 2NO_2(g)$$

If $\Delta H°_{rxn} = -56.52\ kJ \cdot mol^{-1}$ and $\Delta S°_{rxn} = -72.60\ J \cdot K^{-1} \cdot mol^{-1}$ at 298 K, calculate the equilbrium constant for the reaction at 298 K.

__ A. 1.01

__ B. 1.30×10^{6}

__ C. 7.66×10^{-7}

__ D. 1.22×10^{14}

__ E. 8.08×10^{9}

14. At 37 °C, K_w of pure water is 5.0×10^{-14}. What is the pH of pure water at this temperature?

__ A. 7.50

__ B. 7.00

__ C. 6.65

__ D. 7.35

__ E. 6.00

15. Given that the equilibrium constant for the reaction is K,

$P_4(s) + 6Cl_2(g) \rightleftharpoons 4PCl_3(l)$

Calculate the equilibrium constant for the following reaction.

$2PCl_3(l) \rightleftharpoons 1/2\ P_4(s) + 3Cl_2(g)$

__ A. $K^{-1/2}$

__ B. $-2K$

__ C. $-K$

__ D. $-0.5K$

__ E. $K^{1/2}$

16. The conjugate base of $H_2AsO_4^-$ is:

__ A. H_3O^+

__ B. $HAsO_4^{2-}$

__ C. H_2O

__ D. AsO_4^{3-}

__ E. H_3AsO_4

Version B

Answer Key

Read each question carefully before you answer. Work at a steady pace, and you should have ample time to finish. Good Luck!

1. B
2. A
3. B
4. D
5. B
6. A
7. E
8. C
9. D
10. C
11. B
12. E
13. B
14. C
15. A
16. B