Chapter 14 MC Review

1. Which is the correct equilibrium constant expression for the following reaction?
   $Fe_2O_3(s) + 3H_2(g) \rightleftharpoons 2Fe(s) + 3H_2O(g)$
   A. $K_c = [Fe_2O_3]\,[H_2]^3/[Fe]^2[H_2O]^3$
   B. $K_c = [H_2]/[H_2O]$
   C. $K_c = [H_2O]^3/[H_2]^3$
   D. $K_c = [Fe]^2[H_2O]^3/[Fe_2O_3]\,[H_2]^3$
   E. $K_c = [Fe]\,[H_2O]/[Fe_2O_3]\,[H_2]$

2. Consider the two gaseous equilibria
   $SO_2(g) + (\frac{1}{2})O_2(g) \rightleftharpoons SO_3(g)$ K_1
   $2SO_3(g) \rightleftharpoons 2SO_2(g) + O_2(g)$ K_2
   The values of the equilibrium constants K_1 and K_2 are related by
   A. $K_2 = (K_1)^2$
   B. $K_2 = (K_1)^{1/2}$
   C. $K_2 = (K_1)^{-2}$
   D. $K_2 = (K_1)^{-1}$
   E. none of these

3. Carbon tetrachloride reacts at high temperatures with oxygen to produce two toxic gases, phosgene and chlorine.
   $CCl_4(g) + (\frac{1}{2})O_2(g) \rightleftharpoons COCl_2(g) + Cl_2(g)$,
   $K_c = 4.4 \times 10^9$ at 1,000 K
   Calculate K_c for the reaction
   $2CCl_4(g) + O_2(g) \rightleftharpoons 2COCl_2(g) + 2Cl_2(g)$.
   A. 4.4×10^9
   B. 8.8×10^9
   C. 1.9×10^{10}
   D. 1.9×10^{19}
   E. 2.3×10^{-10}

4. Which of these statements is *true* about chemical equilibria *in general*?
   A. At equilibrium the total concentration of products equals the total concentration of reactants, that is, [products] = [reactants].
   B. Equilibrium is the result of the cessation of all chemical change.
   C. There is only one set of equilibrium concentrations that equals the K_c value.
   D. At equilibrium, the rate constant of the forward reaction is equal to the rate constant for the reverse reaction.
   E. At equilibrium, the rate of the forward reaction is equal to the rate of the reverse reaction.

5. When the following reaction is at equilibrium, which of these relationships is *always* true?
   $2NOCl(g) \rightleftharpoons 2NO(g) + Cl_2(g)$
   A. $[NO][Cl_2] = [NOCl]$
   B. $[NO]^2[Cl_2] = [NOCl]^2$
   C. $[NOCl] = [NO]$
   D. $2[NO] = [Cl_2]$
   E. $[NO]^2[Cl_2] = K_c[NOCl]^2$

6. The brown gas NO_2 and the colorless gas N_2O_4 exist in equilibrium, $2NO_2 \rightleftharpoons N_2O_4$. In an experiment, 0.625 mole of N_2O_4 was introduced into a 5.00 L vessel and was allowed to decompose until equilibrium was reached. The concentration of N_2O_4 at equilibrium was 0.0750 M. Calculate K_c for the reaction.
   A. 7.5
   B. 0.125
   C. 0.0750
   D. 0.10
   E. 0.050

7. *If one starts with pure $NO_2(g)$ at a pressure of 0.500 atm, the total pressure inside the reaction vessel when $2NO_2(g) \rightleftharpoons 2NO(g) + O_2(g)$ reaches equilibrium is 0.674 atm. Calculate the equilibrium partial pressure of NO_2.
   A. 0.152 atm
   B. 0.174 atm
   C. 0.200 atm
   D. 0.326 atm
   E. The total pressure cannot be calculated because K_p is not given.

8. Consider the following reactions and their associated equilibrium constants:
   $A + 2B \rightleftharpoons C$ K_1
   $C \rightleftharpoons D + E$ K_2
   For the reaction $A + 2B \rightleftharpoons D + E$, having equilibrium constant K_c,
   A. $K_c = K_1 + K_2$
   B. $K_c = K_1/K_2$
   C. $K_c = K_1 - K_2$
   D. $K_c = (K_1)(K_2)$
   E. $K_c = K_2/K_1$

9. Consider the following equilibria:
   $2SO_3(g) \rightleftharpoons 2SO_2(g) + O_2(g)$ $K_c = 2.3 \times 10^{-7}$
   $2NO_3(g) \rightleftharpoons 2NO_2(g) + O_2(g)$ $K_c = 1.4 \times 10^{-3}$
   Calculate the equilibrium constant for the reaction
   $SO_2(g) + NO_3(g) \rightleftharpoons SO_3(g) + NO_2(g)$.
   A. 78
   B. 1.3×10^{-2}
   C. 1.6×10^{-4}
   D. 3.2×10^{-10}
   E. 6.1×10^3

10. At 700 K, the reaction $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$ has the equilibrium constant $K_c = 4.3 \times 10^6$, and the following concentrations are present: $[SO_2] = 0.10$ M; $[SO_3] = 10.$ M; $[O_2] = 0.10$ M. Is the mixture at equilibrium? If not at equilibrium, in which direction (as the equation is written), *left to right* or *right to left*, will the reaction proceed to reach equilibrium?
    A. Yes, the mixture is at equilibrium.
    B. No, *left to right*
    C. No, *right to left*
    D. There is not enough information to be able to predict the direction.

11. For the following reaction at equilibrium, which choice gives a change that will shift the position of equilibrium to favor formation of more products?
    $2NOBr(g) \rightleftharpoons 2NO(g) + Br_2(g)$, $\Delta H^\circ_{rxn} = 30$ kJ/mol
    A. Increase the total pressure by decreasing the volume.
    B. Add more NO.
    C. Remove Br_2.
    D. Lower the temperature.
    E. Remove NOBr selectively.

12. For the following reaction at equilibrium, which one of the changes below would cause the equilibrium to shift to the *left*?
    $2NOBr(g) \rightleftharpoons 2NO(g) + Br_2(g)$, $\Delta H^\circ_{rxn} = 30$ kJ/mol
    A. Increase the container volume.
    B. Remove some NO.
    C. Remove some Br_2 .
    D. Add more NOBr.
    E. Decrease the temperature.

13. The reaction $2SO_3(g) \rightleftharpoons 2SO_2(g) + O_2(g)$ is endothermic. If the temperature is increased,
    A. more SO_3 will be produced.
    B. K_c will decrease.
    C. no change will occur in K_c .
    D. K_c will increase.
    E. the pressure will decrease.

14. In which of these gas–phase equilibria is the yield of products increased by increasing the total pressure on the reaction mixture?
    A. $CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$
    B. $2NO(g) + Cl_2(g) \rightleftharpoons 2NOCl(g)$
    C. $2SO_3(g) \rightleftharpoons 2SO_2(g) + O_2(g)$
    D. $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$

*Problems 7 and 16 should be solved using ICE

15. Consider this gas phase equilibrium system:
    $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$
    $\Delta H^\circ_{rxn} = +87.8$ kJ/mol.
    Which of these statements is *false*?
    A. Increasing the system volume shifts the equilibrium to the right.
    B. Increasing the temperature shifts the equilibrium to the right.
    C. A catalyst speeds up the approach to equilibrium and shifts the position of equilibrium to the right.
    D. Decreasing the total pressure of the system shifts the equilibrium to the right.
    E. Increasing the temperature causes the equilibrium constant to increase.

16. *For the reaction $2NOCl(g) \rightleftharpoons 2NO(g) + Cl_2(g)$, $K_c = 8.0$ at a certain temperature.
    What concentration of NOCl must be put into an empty 4.00 L reaction vessel in order that the equilibrium concentration of NOCl be 1.00 M?
    A. 1.26 M
    B. 2.25 M
    C. 2.50 M
    D. 3.52 M
    E. 11.0 M

17. The equilibrium constants (pressures in atm) for the chemical reaction
    $N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$ are $K_p = 1.1 \times 10^{-3}$ and 3.6×10^{-3} at 2,200 K and 2,500 K, respectively.
    Which one of these statements is *true*?
    A. The reaction is exothermic, $\Delta H^\circ < 0$.
    B. The partial pressure of NO(g) is less at 2,200 K than at 2,500 K.
    C. Decreasing the volume shifts the equilibrium to the right.
    D. The total pressure at 2,200 K is the same as at 2,500 K.
    E. Higher total pressure shifts the equilibrium to the left.

18. If the reaction $2H_2S(g) \rightleftharpoons 2H_2(g) + S_2(g)$ is carried out at 1065°C, $K_p = 0.0120$. Starting from pure H_2S introduced into an evacuated vessel at 1065°C, what will the total pressure in the vessel be at equilibrium if the equilibrated mixture contains 0.300 atm of $H_2(g)$?
    A. 1.06 atm
    B. 1.36 atm
    C. 2.39 atm
    D. 4.20 atm
    E. 1.51 atm

Answers: 1. C; 2. C; 3. D; 4. E; 5. E; 6. A; 7. A; 8. D; 9. A; 10. B; 11. C; 12. E; 13. D; 14. B; 15. C; 16. D; 17. B; 18. E