CHEMISTRY 1220

CHAPTER 15 PRACTICE EXAM

1. Which is a proper description of chemical equilibrium?

   (A) The frequencies of reactant and product collisions are equal.
   (B) The concentrations of products and reactants are identical.
   (C) The kinetic energy of product and reactant molecules are identical.
   (D) Reactant molecules react to form products as fast as product molecules are reacting to form reactants.
   (E) The formation of reactant molecules to form product molecules has stopped.

2. The value of an equilibrium constant can be used to predict which of the following?

   I. Direction of a reaction
   II. Extent of a reaction
   III. Time required to reach equilibrium

   (A) **I** only (B) **I** and **II** (C) **II** and **III** (D) **I** and **III** (E) **I**, **II** and **III**

3. Consider this reaction

$$2C(s) + O_2(g) \leftrightarrows 2CO(g)$$

What is the equilibrium expression for this reaction?

(A) $K_c = \dfrac{[CO]}{[C][O_2]}$

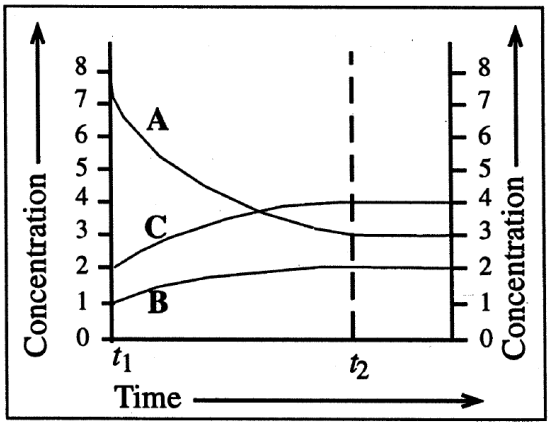
(B) $K_c = \dfrac{[CO]^2}{[C]^2[O_2]}$

(C) $K_c = \dfrac{[2CO]}{[2C]\,[O_2]}$

(D) $K_c = \dfrac{[CO]^2}{[O_2]}$

(E) $K_c = \dfrac{[CO]}{[O_2]}$

4. The graph shows a variation of concentration with time for this reaction at 25 °C.



$$3\mathbf{A}(aq) \leftrightarrow \mathbf{B}(aq) + 2\mathbf{C}(aq)$$

What is the value of the equilibrium constant at time t_2?

(A) 1.2 (B) 0.84 (C) 0.57 (D) 0.28 (E) 0.22

5. Carbon monoxide gas reacts with hydrogen gas at elevated temperatures to form methanol according to this equation.

$$CO(g) + 2H_2(g) \leftrightarrow CH_3OH(g)$$

When 0.40 mol of CO and 0.30 mol of H_2 are allowed to reach equilibrium in a 1.0 L container, 0.060 mol of CH_3OH are formed. What is the value of K_c?

(A) 0.50 (B) 0.98 (C) 1.7 (D) 3.1 (E) 5.4

6. Consider this reaction.

$$\text{heat} + CaSO_3(s) \leftrightarrow CaO(s) + SO_2(g)$$

What will cause an increase in the pressure of $SO_2(g)$ when equilibrium is re-established?

(A) increasing the reaction temperature (B) decreasing the volume of the container

(C) adding some more $CaSO_3$ (D) removing some of the CaO

(E) all of the above

7. Calculate K_c at 303 K for $SO_2(g) + Cl_2(g) \leftrightarrow SO_2Cl_2(g)$ if $K_p = 36.5$ at this temperature.

(A) 36.5 (B) 1.47 (C) 908 (D) 9.19×10^4 (E) 1.45×10^{-2}

8. The K_p for the following equilibrium is 8.5×10^{-3} at 150°C.

$$2IBr\ (g) \leftrightarrow I_2(g) + Br_2(g)$$

If 2.7×10^{-2} atm of IBr is placed in a 2.0 - L container, what is the partial pressure of this substance after equilibrium is reached?

(A) 2.7×10^{-2} atm (B) 2.3×10^{-2} atm (C) 2.5×10^{-2} atm (D) 2.1×10^{-3} atm (E) 2.5×10^{-3} atm

9. Consider the following equilibrium

$$N_2(g) + O_2(g) + Br_2(g) \leftrightarrow 2NOBr(g)$$

Calculate the equilibrium constant, K_p for this reaction given the following (at 298 K):
$2\ NO(g) + Br_2(g) \leftrightarrow 2NOBr(g)$ $K_c = 1.8$
$2\ NO(g) \leftrightarrow N_2(g) + O_2(g)$ $K_c = 1.9 \times 10^{30}$

(A) 9.5×10^{-31} (B) 3.9×10^{-32} (C) 3.4×10^{30} (D) 2.3×10^{-29} (E) 3.8×10^{-34}

10. Cyclopropane (C_3H_6) reacts to form propene (C_3H_6) in the gas phase. The reaction is first order in cylclopropane and has a rate constant of 5.87×10^{-4}/s at 485 ˚C. If a 2.3-L reaction vessel initially contains 722 torr of cyclopropane at 485 ˚C, how long will it take for the partial pressure of cylclopropane to drop to below 105 torr ?

(A) 13.9 sec (B) 4.13 min (C) 195 min (D) 78.4 min (E) 54.7 min

11. Dinitrogen pentoxide decomposes in the gas phase to form nitrogen dioxide and oxygen gas. The reaction is first order in dinitrogen pentoxide and has a half-life of 2.81 hours at 25°C. If a 1.5-L reaction vessel initially contains 735 torr of N_2O_5 at 25°C, what partial pressure of O_2 will be present in the vessel after 230 minutes?

(A) 9.18 torr (B) 225 torr (C) 286 torr (D) 449 torr (E) 163 torr

12. At equilibrium
a) All chemical reactions have ceased.
b) $K_c = (rate_{reverse})(rate_{forward})$
c) The rate constant for the forward reaction equals the rate constant of the reverse reaction.
d) The rate of the forward reaction equals the rate of the reverse reaction.
e) $K_c = (rate_{reverse})/(rate_{forward})$

13. An equilibrium constant with a small magnitude indicates that a system favors _____ when it reaches equilibrium.

a) reactants
b) products
c) neither reactants nor products
d) both reactants and products
e) none of the above

14. Considering the following equilibrium, what is the expression for K?

$$H_2(aq) + I_2(s) \leftrightarrow 2\ HI(aq) \quad \Delta H = 68.0\ kJ/mol$$

a) $[HI]^2/[H_2]$
b) $[H_2][I_2]/[HI]$
c) $([H_2][I_2])^{1/2}/[HI]^2$
d) $[HI]/[H_2]^{1/2}$
e) $[HI]^2/[H_2][I_2]$

15. At a given temperature, $K = 1.3 \times 10^{-2}$ for the reaction

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

Calculate the values of K for each of the following two reactions:

$$1/2\ N_2(g) + 3/2\ H_2(g) \leftrightarrow NH_3(g)$$

$$6\ NH_3(g) \leftrightarrow 3\ N_2(g) + 9\ H_2(g)$$

a) $2.8 \times 10^{4}, 4.5 \times 10^{-2}$
b) $2.65 \times 10^{-4}, 5.3$
c) $0.11, 4.6 \times 10^{5}$
d) $6.8, 7.3 \times 10^{3}$
e) $4.5 \times 10^{-2}, 2.8 \times 10^{4}$

Questions 16-18. An equilibrium mixture of H_2, I_2 and HI at 458^0C contains 1.34 atm of H_2, 1.34 atm of I_2 and 9.30 atm of HI.

$$H_2(g) + I_2(g) \leftrightarrow 2\ HI(g)$$

16. What is the equilibrium constant (K_p) for this reaction?
a) 31.6 b) 48.2 c) 64.7 d) 78.3 e) 92.5

17. The addition of 0.100 mol of HI is made. This is equivalent to adding 1.20 atm of HI pressure. What is the value of Q?
a) 61.4 b) 81.3 c) 98.4 d) 121 e) 148

18. What is the final pressure of $H_2(g)$?
a) 1.07 atm b) 1.27 atm c) 1.37 atm d) 1.47 atm e) 1.57 atm

19. The equilibrium constant for the following reaction is 1.7×10^{-10}. How many moles of AgCl(s) will dissolve in 1.00 L of pure water?

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

a) 1.3×10^{-5} b) 1.7×10^{-1} c) 1.00 d) 1.7×10^{-5} e) 2.9×10^{-20}

20. At 1000 K, the value K_c for the reaction below is $4.08 \times 10_{-3}$.

$$2\ SO_2(g) + O_2(g) \leftrightarrow SO_3(g)$$

You have a mixture of 8.0×10^{-3} M SO_3, 1.6×10^{-2} M SO_2 and 5.2×10^{-4} M O_2. What is the value of Q and which direction must the mixture shift to reach equilibrium?

a) 1.7×10^{-3} right shift
b) 6.0×10^{4} right shift
c) 6.0×10^{4} left shift
d) 1.7×10^{-3} left shift
e) This system is at equilibrium

21. The chemical reaction below has an equilibrium constant of 1.5. What is the final concentration of D at equilibrium if the initial concentrations are [A] = 1.00 M and [B] = 2.00 M?

$$A + B \leftrightarrow C + D$$

a) 0.18
b) 0.39
c) 0.58
d) 0.73
e) 0.92

22. Consider the following reactions at equilibrium. In which cases will the reaction proceed to the right by decreasing the pressure?

1) $CH_3OH\ (g) \leftrightarrow CO(g) + 2\ H_2(g)$
2) $2\ CO(g) \leftrightarrow CO_2(g) + C(s)$
3) $CH_4\ (g) + H_2O(g) \leftrightarrow CO(g) + 3\ H_2(g)$
4) $2\ NH_3(g) \leftrightarrow N_2(g) + 3\ H_2(g)$
5) $2\ CO(g) + O_2(g) \leftrightarrow 2\ CO_2(g)$

a) 1, 2, 3 b) 2, 3, 4 c) 3, 4, 5 d) 2, 3, 5 e) 1, 3, 4

23. For the following exothermic reaction, which condition will shift the equilibrium to the right?

$$4\ HCl(g) + O_2(g) \leftrightarrow 2\ H_2O(g) + 2\ Cl_2(g)$$

a) increasing the temperature
b) increasing the pressure
c) adding a catalyst
d) adding more water
e) more than one of the above is correct

*24. (5 pts) An equilibrium mixture in a 1.00 liter flask contains 4.5 mol of PCl_3 and 1.5 mol of PCl_5. What equilibrium concentration of Cl_2 must be present?

$$PCl_3(g) + Cl_2(g) \leftrightarrow PCl_5(g)\ K_p = 1.9$$

a) 0.065 mol
b) 0.11 mol
c) 0.18 mol
d) 0.24 mol
e) 0.37 mol

25. A mixture of 7.50 g of H_2 and 440. g of Br_2 is heated in a 5.00 L vessel at 600 K. These substances react as shown below. 4.50 g of hydrogen are present at equilibrium. Calculate K.
(MW: H_2 = 2.00, Br_2 = 160.00; HBr = 80.0)

$$H_2(g) + Br_2(g) \leftrightarrow 2\ HBr(g)$$

a) 0.42
b) 4.8×10^{-5}
c) 3.9×10^{-4}
d) 3.2
e) 0.099

26. The equilibrium constant for the following reaction is 256 at a given temperature. If 1.75 mol of H_2 and 1.75 mol of Br_2 are placed in a 1.00 L container at this temperature, what will be the equilibrium concentration of HBr?

$$H_2(g) + Br_2(g) \leftrightarrow 2\ HBr(g)$$

a) 4.18 M
b) 3.11 M
c) 2.44 M
d) 1.82 M
e) 1.14 M

27. If 1.00 mole of HF(g), 0.250 mole of $H_2(g)$ and 0.075 mole of $F_2(g)$ are mixed in a 2.00 L flask, what is the reaction quotient and the net direction to reach equilibrium?

$$2\ HF(g) \leftrightarrow H_2(g) + F_2(g) \quad K = 1.00 \times 10^{-2}$$

a) Q = 0.019, the system is at equilibrium.
b) Q = 0.038, the equilibrium shifts to the right.
c) Q = 0.019, the equilibrium shifts to the left.
d) Q = 0.038, the equilibrium shifts to the left.
e) Q = 0.019, the equilibrium shifts to the right.

28. At 900 K, the reaction $C_2H_6(g) \leftrightarrow C_2H_4(g) + H_2(g)$ has $K_p = 0.0503$. If 2.00 atm of $C_2H_6(g)$ is placed in a container with a metal catalyst at this temperature, what is the equilibrium pressure of $H_2(g)$ in atm?

a) 0.017 atm
b) 1.17 atm
c) 1.84 atm
d) 0.293 atm
e) 0.76 atm

29. Consider the reactions given below. In which case(s) is product formation favored by decreasing the pressure and increasing temperature?

1) $N_2(g) + 3\ H_2(g) \leftrightarrow 2\ NH_3(g)$ $\Delta H = -91.8$ kJ
2) $Ni(CO)_4(g) \leftrightarrow Ni(s) + 4\ CO(g)$ $\Delta H = 160$ kJ
3) $N_2O_4(g) \leftrightarrow 2\ NO_2(g)$ $\Delta H = 58.0$ kJ
4) $2\ NO(g) \leftrightarrow N_2(g) + O_2(g)$ $\Delta H = -181$ kJ
5) $2\ CO\ (g) + O_2(g) \leftrightarrow 2\ CO_2(g)$ $\Delta H = -566$ kJ

a) 4 b) 2, 4 c) 2, 3 d) 2, 4, 5 e) 2, 3, 4

30. Consider the following reaction at equilibrium. Le Chatlier's principle predicts that adding $N_2(g)$ to the system at equilibrium will result in

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

a) a decrease in the concentration of $NH_3(g)$
b) an increase in the value of the equilibrium constant
c) a decrease in the concentration of $H_2(g)$
d) removal of all the $H_2(g)$
e) more than one of the above options.