1) The value of $K_{eq}$ for the equilibrium

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

is 794 at 25°C. What is the value of $K_{eq}$ for the equilibrium below?

$$\frac{1}{2} \ H_2 \ (g) + \frac{1}{2} \ I_2 \ (g) \rightleftharpoons \ HI \ (g)$$

A) 28 \ \ \ \ \ \ \ \ \ \ \ \ B) 1588 \ \ \ \ \ \ \ \ \ \ \ \ C) 0.035 \ \ \ \ \ \ \ \ \ \ \ \ D) 0.0013 \ \ \ \ \ \ \ \ \ \ \ \ E) 397

2) The value of $K_{eq}$ for the equilibrium

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

is 794 at 25°C. At this temperature, what is the value of $K_{eq}$ for the equilibrium below?

$$HI \ (g) \rightleftharpoons \frac{1}{2} \ H_2 \ (g) + \frac{1}{2} \ I_2 \ (g)$$

A) 28 \ \ \ \ \ \ \ \ \ \ \ \ B) 397 \ \ \ \ \ \ \ \ \ \ \ \ C) 0.035 \ \ \ \ \ \ \ \ \ \ \ \ D) 0.0013 \ \ \ \ \ \ \ \ \ \ \ \ E) 1588

3) Consider the following chemical reaction:

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

At equilibrium in a particular experiment, the concentrations of $H_2$, $I_2$, and HI were 0.15 M, 0.033 M, and 0.55 M, respectively. The value of $K_{eq}$ for this reaction is __________.

A) 61 \ \ \ \ \ \ \ \ \ \ \ \ B) 9.0 \times 10^{-3} \ \ \ \ \ \ \ \ \ \ \ \ C) 6.1 \ \ \ \ \ \ \ \ \ \ \ \ D) 111 \ \ \ \ \ \ \ \ \ \ \ \ E) 23

4) Acetic acid is a weak acid that dissociates into the acetate ion and a proton in aqueous solution:

$$HC_2H_3O_2 \ (aq) \rightleftharpoons C_2H_3O_2^- \ (aq) + H^+ \ (aq)$$

At equilibrium at 25°C a 0.100 M solution of acetic acid has the following concentrations:

$[HC_2H_3O_2] = 0.0990 \ M$, $[C_2H_3O_2^-] = 1.33 \times 10^{-3} \ M$, and $[H^+] = 1.33 \times 10^{-3} \ M$. The equilibrium constant, $K_{eq}$ for the ionization of acetic acid at 25°C is __________.

A) $1.75 \times 10^{-7}$
B) $5.71 \times 10^6$
C) 0.100
D) $5.71 \times 10^4$
E) $1.79 \times 10^{-5}$
5) At 22°C, \(K_p = 0.070\) for the equilibrium:

\[
\text{NH}_4\text{HS (s)} \rightleftharpoons \text{NH}_3 (g) + \text{H}_2\text{S (g)}
\]

A sample of solid \(\text{NH}_4\text{HS}\) is placed in a closed vessel and allowed to equilibrate. Calculate the equilibrium partial pressure (atm) of ammonia, assuming that some solid \(\text{NH}_4\text{HS}\) remains.

A) 0.26 \hspace{1cm} B) 4.9 \times 10^{-3} \hspace{1cm} C) 0.52 \hspace{1cm} D) 3.8 \hspace{1cm} E) 0.070

6) A sealed 1.0 L flask is charged with 0.500 mol of \(I_2\) and 0.500 mol of \(\text{Br}_2\). An equilibrium reaction ensues:

\[
I_2 (g) + \text{Br}_2 (g) \rightleftharpoons 2\text{IBr (g)}
\]

When the container contents achieve equilibrium, the flask contains 0.84 mol of \(\text{IBr}\). The value of \(K_{eq}\) is \(\hspace{1cm}\)

A) 4.0 \hspace{1cm} B) 110 \hspace{1cm} C) 2.8 \hspace{1cm} D) 6.1 \hspace{1cm} E) 11

7) Which of the following expressions is the correct equilibrium-constant expression for the equilibrium between dinitrogen tetroxide and nitrogen dioxide?

\[
\text{N}_2\text{O}_4 (g) \rightleftharpoons 2\text{NO}_2 (g)
\]

A) \([\text{NO}_2]^2[\text{N}_2\text{O}_4]\)  
B) \(\frac{[\text{NO}_2]^2}{[\text{N}_2\text{O}_4]}\)  
C) \(\frac{[\text{NO}_2]}{[\text{N}_2\text{O}_4]}\)  
D) \(\frac{[\text{NO}_2]}{[\text{N}_2\text{O}_4]^2}\)  
E) \([\text{NO}_2][\text{N}_2\text{O}_4]\)

8) Given the following reaction at equilibrium at 300.0 K:

\[
\text{NH}_4\text{HS (s)} \rightleftharpoons \text{NH}_3 (g) + \text{H}_2\text{S (g)}
\]

If \(p_{\text{NH}_3} = p_{\text{H}_2\text{S}} = 0.111\) atm, \(K_p = \hspace{1cm}\).

A) 1.23 \times 10^{-2}  
B) 8.12 \times 10^{-2}  
C) 1.11 \times 10^{-1}  
D) 4.99 \times 10^{-4}  
E) 5.66 \times 10^{-3}
9) The equilibrium constant for reaction 1 is K. The equilibrium constant for reaction 2 is ________.

(1) \( \text{SO}_2 (g) + \frac{1}{2} \text{O}_2 (g) \rightleftharpoons \text{SO}_3 (g) \)
(2) \( 2\text{SO}_3 (g) \rightleftharpoons 2\text{SO}_2 (g) + \text{O}_2 (g) \)

A) \( K^2 \) B) \( \frac{1}{2K} \) C) \(-K^2\) D) \( 2K \) E) \( \frac{1}{K^2} \)

10) The \( K_{\text{eq}} \) for the equilibrium below is \( 7.52 \times 10^{-2} \) at 480.0°C.

\( 2\text{Cl}_2 (g) + 2\text{H}_2\text{O} (g) \rightleftharpoons 4\text{HCl} (g) + \text{O}_2 (g) \)

What is the value of \( K_{\text{eq}} \) at this temperature for the following reaction?

\( 2\text{HCl} (g) + \frac{1}{2} \text{O}_2 (g) \rightleftharpoons \text{Cl}_2 (g) + \text{H}_2\text{O} (g) \)

A) \( 5.66 \times 10^{-3} \)
B) 0.274
C) 3.65
D) 13.3
E) \(-0.0376\)

11) Nitrosyl bromide decomposes according to the following equation.

\( 2\text{NOBr} (g) \rightleftharpoons 2\text{NO} (g) + \text{Br}_2 (g) \)

A sample of NOBr (0.64 mol) was placed in a 1.00-L flask containing no NO or Br_2. At equilibrium the flask contained 0.46 mol of NOBr. How many moles of NO and Br_2, respectively, are in the flask at equilibrium?

A) 0.46, 0.23 B) 0.46, 0.46 C) 0.18, 0.360 D) 0.18, 0.090 E) 0.18, 0.18

12) At 400 K, the equilibrium constant for the reaction

\( \text{Br}_2 (g) + \text{Cl}_2 (g) \rightleftharpoons 2\text{BrCl} (g) \)

is \( K_p = 7.0 \). A closed vessel at 400 K is charged with 1.00 atm of \( \text{Br}_2 \) (g), 1.00 atm of \( \text{Cl}_2 \) (g), and 2.00 atm of \( \text{BrCl} \) (g). Use \( Q \) to determine which of the statements below is true.

A) The equilibrium partial pressures of \( \text{Br}_2 \), \( \text{Cl}_2 \), and \( \text{BrCl} \) will be the same as the initial values.
B) The reaction will go to completion since there are equal amounts of \( \text{Br}_2 \) and \( \text{Cl}_2 \).
C) The equilibrium partial pressure of \( \text{BrCl} \) (g) will be greater than 2.00 atm.
D) The equilibrium partial pressure of \( \text{Br}_2 \) will be greater than 1.00 atm.
E) At equilibrium, the total pressure in the vessel will be less than the initial total pressure.
13) The equilibrium expression for $K_p$ for the reaction below is 

$$2O_3 \ (g) \rightleftharpoons 3O_2 \ (g)$$

A) $\frac{P_{O_3}^2}{P_{O_2}^3}$  
B) $\frac{3P_{O_2}}{2P_{O_3}}$  
C) $\frac{P_{O_2}^3}{P_{O_3}^2}$  
D) $\frac{2P_{O_3}}{3P_{O_2}}$  
E) $\frac{3P_{O_3}}{2P_{O_2}}$

14) The equilibrium constant for the gas phase reaction

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

is $K_{eq} = 4.34 \times 10^{-3}$ at 300°C. At equilibrium, 

A) reactants predominate  
B) only reactants are present  
C) only products are present  
D) roughly equal amounts of products and reactants are present  
E) products predominate

15) Given the following reaction at equilibrium, if $K_c = 6.44 \times 10^5$ at 230.0°C, $K_p =$

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

A) $1.56 \times 10^4$  
B) $6.44 \times 10^5$  
C) $2.67 \times 10^7$  
D) $2.66 \times 10^6$  
E) $3.67 \times 10^{-2}$

16) At equilibrium, 

A) the rate constants of the forward and reverse reactions are equal  
B) the rates of the forward and reverse reactions are equal  
C) all chemical reactions have ceased  
D) the value of the equilibrium constant is 1  
E) the limiting reagent has been consumed

17) At elevated temperatures, molecular hydrogen and molecular bromine react to partially form hydrogen bromide:

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

A mixture of 0.682 mol of $H_2$ and 0.440 mol of $Br_2$ is combined in a reaction vessel with a volume of 2.00 L. At equilibrium at 700 K, there are 0.566 mol of $H_2$ present. At equilibrium, there are 

mol of $Br_2$ present in the reaction vessel.

A) 0.232  
B) 0.324  
C) 0.000  
D) 0.440  
E) 0.566
18) The reaction below is exothermic:

\[ 2\text{SO}_2 (g) + \text{O}_2 (g) \rightleftharpoons 2\text{SO}_3 (g) \]

Le Chatelier's Principle predicts that ________ will result in an increase in the number of moles of \text{SO}_3 (g) in the reaction container.
A) removing some oxygen
B) increasing the pressure
C) increasing the volume of the container
D) decreasing the pressure
E) increasing the temperature

19) Consider the following reaction at equilibrium:

\[ 2\text{CO}_2 (g) \rightleftharpoons 2\text{CO} (g) + \text{O}_2 (g) \quad \Delta H^\circ = -514 \text{ kJ} \]

Le Chatelier's principle predicts that an increase in temperature will ________.
A) decrease the partial pressure of \text{CO}_2 (g)
B) decrease the value of the equilibrium constant
C) increase the value of the equilibrium constant
D) increase the partial pressure of \text{O}_2 (g)
E) increase the partial pressure of \text{CO}

20) Consider the following reaction at equilibrium:

\[ 2\text{NH}_3 (g) \rightleftharpoons \text{N}_2 (g) + 3\text{H}_2 (g) \]

Le Chatelier's principle predicts that the moles of \text{H}_2 in the reaction container will increase with ________.
A) some removal of \text{NH}_3 from the reaction vessel (V and T constant)
B) an increase in total pressure by the addition of helium gas (V and T constant)
C) addition of some \text{N}_2 to the reaction vessel (V and T constant)
D) a decrease in the total volume of the reaction vessel (T constant)
E) a decrease in the total pressure (T constant)

21) Consider the following reaction at equilibrium:

\[ \text{C (s)} + \text{H}_2\text{O} (g) \rightleftharpoons \text{CO} (g) + \text{H}_2 (g) \]

Which of the following conditions will increase the partial pressure of \text{CO}?
A) increasing the amount of carbon in the system
B) decreasing the volume of the reaction vessel
C) removing \text{H}_2\text{O} (g) from the system
D) decreasing the pressure in the reaction vessel
E) decreasing the partial pressure of \text{H}_2\text{O} (g)
22) The effect of a catalyst on an equilibrium is to _________.
   A) increase the equilibrium constant so that products are favored
   B) increase the rate of the forward reaction only
   C) slow the reverse reaction only
   D) shift the equilibrium to the right
   E) increase the rate at which equilibrium is achieved without changing the composition of the equilibrium mixture

23) In which of the following reactions would increasing pressure at constant temperature not change the concentrations of reactants and products, based on Le Chatelier's principle?
   A) \( \text{N}_2\text{O}_4 (g) \rightleftharpoons 2\text{NO}_2 (g) \)
   B) \( 2\text{N}_2 (g) + \text{O}_2 (g) \rightleftharpoons 2\text{N}_2\text{O} (g) \)
   C) \( \text{N}_2 (g) + 3\text{H}_2 (g) \rightleftharpoons 2\text{NH}_3 (g) \)
   D) \( \text{N}_2 (g) + \text{O}_2 (g) \rightleftharpoons 2\text{NO} (g) \)
   E) \( \text{N}_2 (g) + 2\text{O}_2 (g) \rightleftharpoons 2\text{NO}_2 (g) \)

24) Consider the following reaction at equilibrium:
   \[ 2\text{SO}_2 (g) + \text{O}_2 (g) \rightleftharpoons 2\text{SO}_3 (g) \quad \Delta H^\circ = -99 \text{ kJ} \]

   Le Chatelier's principle predicts that an increase in temperature will result in _________.
   A) an increase in \( K_{eq} \)
   B) the partial pressure of \( \text{O}_2 \) will decrease
   C) a decrease in the partial pressure of \( \text{SO}_2 \)
   D) a decrease in the partial pressure of \( \text{SO}_3 \)
   E) no changes in equilibrium partial pressures

25) Phosphorous trichloride and phosphorous pentachloride equilibrate in the presence of molecular chlorine according to the reaction:
   \[ \text{PCl}_3 (g) + \text{Cl}_2 (g) \rightarrow \text{PCl}_5 (g) \]

   An equilibrium mixture at 450 K contains
   \( \text{PPCl}_3 = 0.202 \text{ atm}, \)
   \( \text{PCl}_2 = 0.256 \text{ atm}, \) and
   \( \text{PPCl}_5 = 3.45 \text{ atm}. \) What is the value of \( K_p \) at this temperature?
   A) 2.99
   B) 7.54
   C) 66.7
   D) \( 1.78 \times 10^{-1} \)
   E) \( 1.50 \times 10^{-2} \)