Chemical Equilibrium Worksheet

Organic Chemistry Tutor

1. Write the equilibrium expression K_C and K_P for the following reaction:

$$1\ N_{2\,(g)} + 3\ H_{2\,(g)} \leftrightarrow 2\ NH_{3\,(g)}$$

2. Nitrogen gas reacts with Chlorine gas to produce gaseous Nitrogen Trichloride. At equilibrium, the concentration of each gas was found to be $[N_2]$ = 0.15 M, $[Cl_2]$ = 0.25 M, and $[NCl_3]$ = 0.50 M. Calculate the value of the equilibrium constant K_C.

3. Sulfur Dioxide reacts with Oxygen gas to produce gaseous Sulfur Trioxide. At equilibrium, the partial pressures of each gas were found to be 0.10 atm, 0.30 atm, and 0.45 atm for SO_2, O_2, and SO_3 respectively. Calculate the equilibrium constant K_P.

4. If K_C for the reaction shown below is 9.60 at 300^0 C, what is the value of the K_P at this temperature? (b) If $K_P = 1.45 \times 10^{-3}$ at 500^0 C, what is the value of K_C at this temperature?

$$1\ N_{2\,(g)} + 3\ H_{2\,(g)} \leftrightarrow 2\ NH_{3\,(g)}$$

5. Given the value of K for the reaction shown below, what is the value of K' for the adjusted reaction?

$$2\ NO + 1\ O_2 \leftrightarrow 2\ NO_2 \qquad K = 100$$

$$4\ NO + 2\ O_2 \leftrightarrow 4\ NO_2 \qquad K' = ?$$

6. 20 mol of NOCl is placed inside an empty 4.0 L container. At equilibrium, 8.0 mol of Cl_2 was found to be in the container. Calculate the value of K_C for this reaction.

$$2\ NOCl_{(g)} \leftrightarrow 2\ NO_{(g)} + 1\ Cl_{2\,(g)}$$

7. Carbon Monoxide reacts with Oxygen gas to produce Carbon Dioxide. At equilibrium, the concentrations of O_2 and CO_2 are 0.10 M and 0.75 M respectively. If $K_C = 4 \times 10^3$, what is the concentration of CO at equilibrium?

8. At a certain temperature, Ammonia partially decomposes into Nitrogen gas and Hydrogen gas. Ammonia was added to an empty container until the partial pressure of NH_3 reached 0.85 atm. At equilibrium, the partial pressure of H_2 was found to be 0.45 atm. What is the partial pressure of NH_3 at equilibrium?

9. Gaseous Hydroiodic Acid decomposes into Hydrogen gas and Iodine gas at high temperatures. At a certain temperature, $K_C = 400$. If 8 moles of HI were added to a 5.0L container, what will be the concentration of HI at equilibrium?

10. Which of the following statements is false regarding a chemical reaction that is at equilibrium?

A. The rate of the forward reaction is equal to the rate of the reverse reaction.

B. The addition of a catalyst will not affect the value of the equilibrium constant.

C. Increasing the temperature will change the value of the equilibrium constant.

D. The equilibrium constant K is equal to the value of k_F / k_R.

E. The equilibrium constant K is dependent on the concentration of the reactants and products.

11. A certain chemical reaction is at equilibrium. K_{eq} for this reaction is 1×10^8. Which of the following statements is true?

I. The reaction is product favored.
II. The position of equilibrium lies far to the left.
III. The concentrations of the reactants and products will not change because the forward and reverse reactions have stopped.
IV. The concentrations of the reactants and products will not change because the rates of the forward and reverse reactions are equal.

A. I and III
B. I and IV
C. II and III
D. II and IV
E. I, II, and IV

12. Ammonium Carbamate decomposes into Ammonia and Carbon Dioxide as shown in the reaction below. (a) Write the equilibrium expression for K_C and K_P for the reaction. (b) When 10g of Ammonium Carbamate is placed in a sealed empty container, the total pressure inside was found to be 0.27 atm at equilibrium. What is the value of K_P for this reaction?

$$\mathbf{1\ NH_4CO_2NH_{2\,(s)} \leftrightarrow 2\ NH_{3\,(g)} + 1\ CO_{2\,(g)}}$$

13. 100 of Iron metal is mixed with steam inside a container. The partial pressure of steam is initially at 3 atm. K_P for the reaction shown below is 50 at a certain high temperature. (a) What is the partial pressure of H_2 at equilibrium? (b) What is the total pressure inside the container at equilibrium?

$$3\ Fe_{(s)} + 4\ H_2O_{(g)} \leftrightarrow 1\ Fe_3O_{4\,(s)} + 4\ H_{2\,(g)}$$

14. Given the K values for the 1st two reactions, what is the value of K for the 3rd reaction shown below?

$2\ NOBr_{(g)} \leftrightarrow 2\ NO_{(g)} + 1\ Br_{2(g)}$ $K_1 = 0.07$

$1\ Br_{2\,(g)} + 1\ Cl_{2\,(g)} \leftrightarrow 2\ BrCl_{(g)}$ $K_2 = 36$

$2\ NOBr_{(g)} + 1\ Cl_{2\,(g)} \leftrightarrow 2NO_{(g)} + 2\ BrCl_{(g)}$ $K_3 = ?$

15. What is the K value for the reaction shown below?

$6\ D + 4\ F \leftrightarrow 8\ C + 4\ B$ $K_1 = 0.05$

$2\ C \leftrightarrow A + 2\ B$ $K_2 = 0.01$

$2\ A + 6\ B \leftrightarrow 3\ D + 2\ F$ $K_3 = ?$

16. Which of the following answer choices correctly describes the relationship between K_P and K_C for the reaction shown below?

$$1\ Br_{2\,(g)} + 1\ Cl_{2\,(g)} \leftrightarrow 2\ BrCl_{(g)}$$

A. $K_P = K_C\ (RT)$
B. $K_P = K_C$
C. $K_P = K_C\ (RT)^{-2}$
D. $K_P = K_C\ (RT)^{-1}$

17. Dinitrogen Monoxide is initially mixed with Oxygen gas in a sealed container. At equilibrium, the concentrations in the container were found to be: $[N_2O]$ = 2.30 M, $[O_2]$ = 1.65 M, and [NO] = 1.40 M. What were the initial concentrations of N_2O and O_2?

$$2\ N_2O_{(g)} + 1\ O_{2\,(g)} \leftrightarrow 4\ NO_{(g)}$$

18. Hydrogen reacts with Bromine to form Hydrobromic Acid as shown in the reaction below. The initial concentrations of H_2, Br_2, and HBr are 2.0 M, 3.0 M, and 0.50 M respectively. Which of the following statements is true?

$$1\ H_{2\,(g)} + 1\ Br_{2\,(g)} \leftrightarrow 2\ HBr_{(g)} \qquad K = 2 \times 10^{-3}$$

A. The reaction is in a state of dynamic equilibrium.
B. The reaction will shift to the right.
C. The concentration of H_2 will increase.
D. The concentration of Br_2 will decrease.
E. The value of Q will increase until it equals K.

19. A certain amount of HI is added to an empty reaction vessel. At equilibrium, the concentration of HI was found to be 0.50 M. (a) What is the equilibrium concentration of H_2? (b) What was the initial concentration of HI?

$$2\ HI_{(g)} \leftrightarrow 1\ H_{2\,(g)} + 1\ I_{2\,(g)} \qquad K = 0.045$$

20. 9 mol of NO_2 was placed in a 3.0 L container. At equilibrium, it was found that 70% of NO_2 had dissociated into NO and O_2. What is the value of the equilibrium constant for this reaction?

$$2\ NO_{2\,(g)} \leftrightarrow 2\ NO_{(g)} + 1\ O_{2\,(g)}$$

21. The initial concentrations of PCl_3, Cl_2, and PCl_5 in a reaction vessel are 0.485 M, 0.261 M, and 0.399 M respectively. $K_C = 0.500$. Calculate the equilibrium concentration of Cl_2.

22. 3 mol of CO_2 and 2 mol of CO are placed in a 1.0L reaction vessel. $K_C = 5 \times 10^{-4}$. Calculate the equilibrium concentration of all species in this reaction.

$$\mathbf{2\ CO_{2\,(g)} \leftrightarrow 2\ CO_{(g)} + 1\ O_{2\,(g)}}$$

23. Which of the following reactions will not be affected by changes in volume or pressure?

A. $PCl_{3\,(g)} + Cl_{2\,(g)} \leftrightarrow PCl_{5\,(g)}$

B. $2\ SO_{2\,(g)} + O_{2\,(g)} \leftrightarrow 2\ SO_{3\,(g)}$

C. $H_{2\,(g)} + Cl_{2\,(g)} \leftrightarrow 2\ HCl_{(g)}$

D. $CaCO_{3\,(s)} \leftrightarrow CO_{2\,(g)} + CaO_{(s)}$

24. Which of the following conditions will maximize the yield of NH_3 in the reaction shown below?

$$\mathbf{1\ N_{2\,(g)} + 3\ H_{2\,(g)} \leftrightarrow 2\ NH_{3\,(g)}} \quad \Delta H = -\ \text{(exothermic)}$$

A. Low temperature and high pressure
B. Low temperature and low pressure
C. High temperature and low pressure
D. High temperature and high pressure
E. None of the above

25. Using the data shown in the table below, is the following reaction endothermic or exothermic?

$$1\ A_{(s)} + 2\ B_{(g)} \leftrightarrow 1\ C_{(g)}$$

Temperature	Keq
400 K	4.6 x 10^-5
600 K	3.1 x 10^-4
800 K	5.7 x 10^-3
1200 K	7.4 x 10^-1

Answers:

1. C
2. $K_C = 106.7$
3. $K_P = 67.5$

4a. $K_P = 4.34 \times 10^{-3}$

4b. $K_C = 5.83$

5. K' = 10,000
6. $K_C = 32$
7. [CO] = 0.0375 M
8. $P_{NH3} = 0.55$ atm
9. [HI] = 0.039 M
10. E
11. B

12a. $K_C = [NH_3]^2[CO_2]$, $K_P = P_{NH3}^2 * P_{CO2}$

12b. $K_P = 2.916 \times 10^{-3}$

13a. $P_{H2} = 2.18$ atm

13b. $P_T = 3.00$ atm

14. $K_3 = 2.52$
15. $K_3 = 4.47 \times 10^4$
16. B
17. $[N_2O]_0 = 3.0M$, $[O_2]_0 = 2.0$ M
18. C

19a. $[H_2]_{eq} = 0.106$ M

19b. $[HI]_0 = 0.712$ M

20. $K_C = 5.72$
21. $[Cl_2]_{eq} = 0.487$ M
22. $[CO_2]_{eq} = 3.00$ M, $[CO]_{eq} = 2.00$ M, $[O_2]_{eq} = 1.125 \times 10^{-3}$ M
23. C
24. A
25. Endothermic