

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

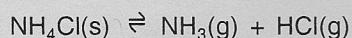
1. Consider the chemical reaction, $\text{CO(g)} + \text{Cl}_2\text{(g)} \rightleftharpoons \text{COCl}_2\text{(g)}$; $K = 4.6 \times 10^9 \text{ M}^{-1}$. How do the equilibrium concentrations of the reactants compare to the equilibrium concentration of the product?
 - A. They have to be exactly equal.
 - 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.
$$\text{A(g)} + 2\text{B(g)} \rightleftharpoons \text{C(g)}$$
At equilibrium, the concentration of A is $0.300 \text{ mol}\cdot\text{L}^{-1}$. What is the concentration of B at equilibrium?
 - A. $0.434 \text{ mol}\cdot\text{L}^{-1}$
 - B. $0.500 \text{ mol}\cdot\text{L}^{-1}$
 - C. $0.300 \text{ mol}\cdot\text{L}^{-1}$
 - D. $0.600 \text{ mol}\cdot\text{L}^{-1}$
 - E. none of these.

3. Consider the reaction from the previous question, $\text{A(g)} + 2\text{B(g)} \rightleftharpoons \text{C(g)}$ [2.00 moles of A and 3.00 moles of B are placed in a 6.00 L container]. At equilibrium, the concentration of A is $0.300 \text{ mol}\cdot\text{L}^{-1}$. What is the value of K ?
 - A. 0.253 M^{-2}
 - B. 0.0584 M^{-2}
 - C. 0.146 M^{-2}
 - D. 5.309 M^{-2}
 - E. 0.300 M^{-2}

4. Consider the chemical reaction: $\text{H}_2\text{(g)} + \text{I}_2\text{(s)} \rightleftharpoons 2\text{HI(g)}$; $\Delta H = +68.0 \text{ kJ}\cdot\text{mol}^{-1}$. Which of the following statements about the equilibrium 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 $\text{I}_2\text{(s)}$ has no effect on the equilibrium.
 - D. Adding more $\text{H}_2\text{(g)}$ increases the value of the equilibrium 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.

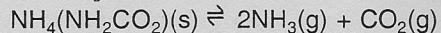
5. A 10.0 g sample of solid $\text{NH}_4\text{Cl}(s)$ is heated in a 5.00 L container at 900 °C. At equilibrium the pressure of $\text{NH}_3(g)$ is 1.20 atm.



The equilibrium constant K_p , for the reaction is:

- A. 31.0 atm²
- B. 1.44 atm²
- C. 2.40 atm²
- D. 1.20 atm²
- E. none of these.

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



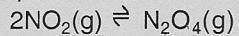
Calculate K_p at 25 °C for this reaction.

- A. $2.31 \times 10^{-4} \text{ atm}^3$
- B. $9.45 \times 10^{-6} \text{ atm}^3$
- C. $2.64 \times 10^{-11} \text{ atm}^3$
- D. $2.40 \times 10^{-7} \text{ atm}^3$
- E. $1.09 \times 10^{-12} \text{ atm}^3$

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

- A. A system moves spontaneously toward a state of equilibrium.
- B. A chemical system that is disturbed from an equilibrium condition responds in a manner to restore equilibrium.
- C. Equilibrium in chemical systems is dynamic, with two opposing processes balancing one another.
- D. The value of the equilibrium 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.

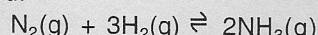
8. At a certain temperature K for the reaction



is $7.5 \text{ L}\cdot\text{mol}^{-1}$. If 2.0 moles of $\text{NO}_2(g)$ are placed in a 2.0 L container and permitted to react at this temperature, calculate the concentration of $\text{N}_2\text{O}_4(g)$ 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 $\text{N}_2(\text{g})$ and 4.0 moles of $\text{H}_2(\text{g})$ were added to a 1.0 L container and the following reaction then occurred:



The equilibrium concentration of $\text{NH}_3(\text{g}) = 0.68 \text{ mol}\cdot\text{L}^{-1}$ at 700 °C. The value for K at 700 °C for the formation of $\text{NH}_3(\text{g})$ is:

- A. $3.4 \times 10^{-2} \text{ L}^2\cdot\text{mol}^{-2}$
- B. $3.1 \times 10^{-3} \text{ L}^2\cdot\text{mol}^{-2}$
- C. $1.3 \times 10^{-1} \text{ L}^2\cdot\text{mol}^{-2}$
- D. $1.1 \times 10^{-2} \text{ L}^2\cdot\text{mol}^{-2}$
- E. none of these.

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

- A. $2\text{Hg}(\text{l}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{HgO}(\text{s})$
- B. $4\text{NH}_3(\text{g}) + 5\text{O}_2(\text{g}) \rightleftharpoons 4\text{NO}(\text{g}) + 6\text{H}_2\text{O}(\text{g})$
- C. $\text{N}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{NO}(\text{g})$
- D. $\text{CuSO}_4(\text{s}) \rightleftharpoons \text{CuO}(\text{s}) + \text{SO}_3(\text{g})$
- E. $\text{CO}_2(\text{g}) + \text{C}(\text{s}) \rightleftharpoons 2\text{CO}(\text{g})$

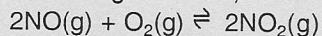
11. At 699 K, $\Delta G^\circ_{\text{rxn}} = -23.25 \text{ kJ}\cdot\text{mol}^{-1}$ for the reaction $\text{H}_2(\text{g}) + \text{F}_2(\text{g}) \rightleftharpoons 2\text{HF}(\text{g})$. Calculate the ΔG_{rxn} for this reaction when the partial pressure of $\text{H}_2(\text{g})$ and $\text{F}_2(\text{g})$ are 10.0 atm each and the partial of $\text{HF}(\text{g})$ is 1.00 atm.

- A. $+36.6 \text{ kJ}\cdot\text{mol}^{-1}$
- B. $-50.0 \text{ kJ}\cdot\text{mol}^{-1}$
- C. $-36.6 \text{ kJ}\cdot\text{mol}^{-1}$
- D. $-3.5 \text{ kJ}\cdot\text{mol}^{-1}$
- E. $+3.5 \text{ kJ}\cdot\text{mol}^{-1}$

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

- A. $1.0 \times 10^{-14} \text{ M}$
- B. $1.6 \times 10^{-6} \text{ M}$
- C. 0.91 M
- D. $1.4 \times 10^{-3} \text{ M}$
- E. $6.3 \times 10^{-9} \text{ M}$

13. Consider the following reaction,



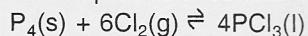
If $\Delta H^\circ_{\text{rxn}} = -56.52 \text{ kJ}\cdot\text{mol}^{-1}$ and $\Delta S^\circ_{\text{rxn}} = -72.60 \text{ J}\cdot\text{K}^{-1}\cdot\text{mol}^{-1}$ at 298 K, calculate the equilibrium constant for the reaction at 298 K.

- A. 1.01
- B. 1.30×10^6
- C. 7.66×10^{-7}
- D. 1.22×10^{14}
- E. 8.08×10^9

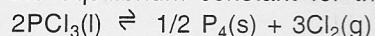
14. At 37 °C, K_w of pure water is 5.0×10^{-14} . What is the pH of pure water at this temperature?

- 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 ,



Calculate the equilibrium constant for the following reaction.



- 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

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