

Unit 3: Equilibrium /55

Practice Exam

Multiple Choice:

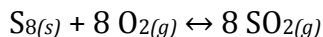
1. If nitrogen monoxide and oxygen can be made into nitrogen dioxide, what is the reverse reaction?
2. At equilibrium, what is the rate of the production of reactants compared with the rate of production of the products?
3. For a chemical reaction at equilibrium, which of the following statements is false? (4 choices, from notes/lessons)
4. What is the value of K_{eq} dependent upon?
5. K_{eq} for the reaction: $N_2O_{4(g)} \rightleftharpoons 2 NO_{2(g)}$ is 4.8×10^{-3} at $25^\circ C$. Which of the following sets of concentrations represents equilibrium conditions?
 - a) $[N_2O_4] = 4.8 \times 10^{-1}$ $[NO_2] = 1.0 \times 10^{-4}$
 - b) $[N_2O_4] = 4.8 \times 10^{-4}$ $[NO_2] = 1.0 \times 10^{-1}$
 - c) $[N_2O_4] = 1.0 \times 10^{-1}$ $[NO_2] = 4.8 \times 10^{-4}$
 - d) $[N_2O_4] = 2.2 \times 10^{-2}$ $[NO_2] = 1.0 \times 10^{-1}$
 - e) $[N_2O_4] = 1.0 \times 10^{-1}$ $[NO_2] = 2.2 \times 10^{-2}$
6. When K_{eq} is much smaller than 1, _____
 - a) the concentration of the products is very large compared with the reactants
 - b) the concentration of the products is very small compared with the reactants
 - c) the concentration of the reactants is very small compared with the products
 - d) the concentration of the reactants and products are approximately the same
7. What happens to a reaction at equilibrium when a product concentration is increased?
 - a) The reaction makes more products.
 - b) The reaction makes more reactants.
 - c) A catalyst is formed
 - d) The reaction is unchanged.
8. What happens to a reaction at equilibrium when a reactant concentration is decreased?
 - a) The reaction makes more products.
 - b) The reaction makes more reactants.
 - c) A catalyst is formed
 - d) The reaction is unchanged.
9. Consider the gaseous equilibrium
$$PCl_3 + Cl_2 \leftrightarrow PCl_5$$
In which direction will this reaction move if the reaction volume is decreased?
10. Consider the gaseous equilibrium $PCl_3 + Cl_2 \leftrightarrow PCl_5$
In which direction will this reaction move with the addition of helium gas?

11. A catalyst is added to the equilibrium reaction



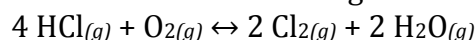
The reaction will...

12. Consider the equilibrium



In which direction will this reaction move if more sulfur is added to the reaction vessel?

13. What could you do to shift the following reaction to the left?

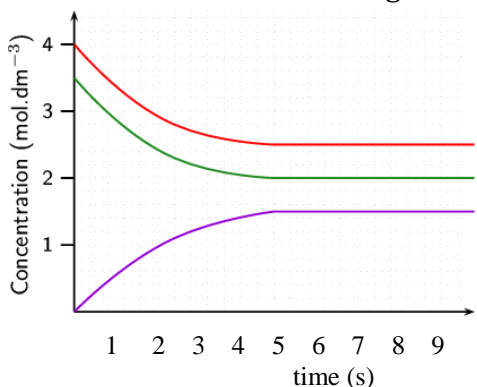


14. In an endothermic reaction at equilibrium, what is the effect of lowering the temperature?

15. What changes could you make to the haber process to produce more products?

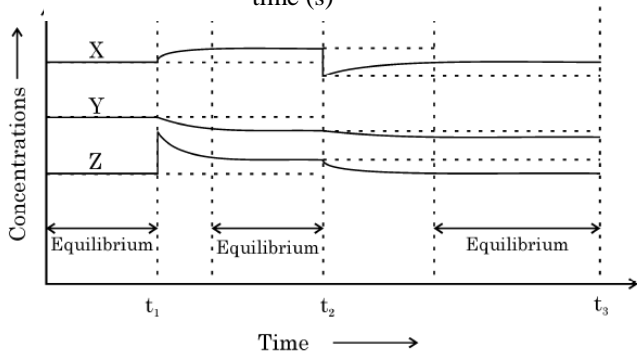
16. If Q is less than your K_{eq} for a given reaction, that means:

- The reaction will proceed in the reverse direction
- The reaction will proceed in the forward direction
- The reaction is at equilibrium
- The reaction will go to completion



17. At what time does the reaction reach equilibrium?

18. ← Another question about an equilibrium graph



19. The reaction is initially at equilibrium and has a stress applied at t_1 and t_2 . The equation for the reaction is

- $\text{Y} + \text{Z} \rightleftharpoons \text{X}$
- $\text{Z} + \text{X} \rightleftharpoons \text{Y}$
- $\text{Z} \rightleftharpoons \text{X} + \text{Y}$
- not possible to determine from the information given.

20. What possible stress could have been applied to the system at t_1 ?

21. What stress could have been applied to the system at t_2 ?

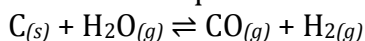
22. If all species are gases, and at t_3 the volume of the container was increased, finish the graph by drawing the resulting concentration lines/curves.

Short Answer

1. Write the reaction equation and the equilibrium expression for each of the following: (2 marks)
The reversible reaction of carbon monoxide gas and nitrogen monoxide gas creating gaseous nitrogen and carbon dioxide gas.

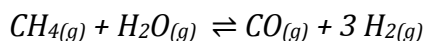
2. List 2 criteria that characterize an equilibrium system: (2 marks)

3. What is the equilibrium expression for the following reaction: (1 mark)



4. What is the K_{eq} expression for the following gaseous reaction: $2 SO_2 + O_2 \rightarrow 2 SO_3$ (1 mark)

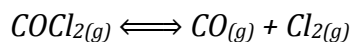
5. At 1000°C, methane reacts with water as follows:



In one experiment the equilibrium concentrations of the gases were $[CH_4] = 2.97 \times 10^{-3}$, $[H_2O] = 7.94 \times 10^{-3}$, $[CO] = 5.45 \times 10^{-3}$, and $[H_2] = 2.1 \times 10^{-3}$. Calculate K_{eq} at this temperature. (2 marks)

6. If K_{eq} for the reaction $N_{2(g)} + 3 H_{2(g)} \rightleftharpoons 2 NH_{3(g)}$ is 2.37×10^{-3} at a particular temperature, what is K_{eq} for the reverse reaction at the same temperature? (1 mark)

7. Gaseous phosgene (COCl_2) is placed in a flask and allowed to reach equilibrium at 100°C .



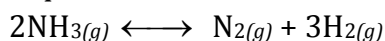
At the temperature of the reaction, the value of the equilibrium constant is 2.2×10^{-10} . The concentration of the phosgene at equilibrium is 0.104 M. Calculate the concentration of carbon monoxide at equilibrium. (3 marks)

8. At 900K, a 4.00 L reaction vessel originally contained 4.4 mol of $\text{PCl}_{5(g)}$. At equilibrium, 1.32 mol of $\text{Cl}_{2(g)}$ had been produced. Calculate K_{eq} . The equation for the reaction is



(4 marks)

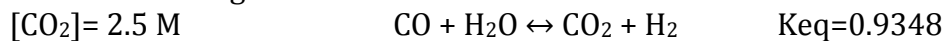
9. At 27°C the following reaction has an equilibrium constant value of 2.63×10^{-9}



If 1.00M NH_3 gas is placed in a flask, calculate the concentration of hydrogen at equilibrium. *HINT: You may have to make an approximation. You do not have to use the quadratic formula.* (4 mark)

10. Explain why if the $Q > K_{eq}$ the reaction shifts in the reverse direction. (2 marks) ← use your flipbook to help you

11. The following are initial concentrations of chemicals in the following reaction:



$$[H_2] = 2.5 \text{ M}$$

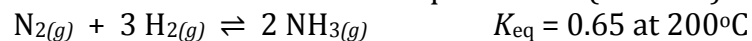
$$[CO] = 0.40 \text{ M}$$

$$[H_2O] = 0.40 \text{ M}$$

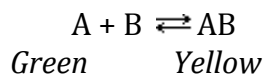
a) Calculate which direction will the reaction shift to reach equilibrium? (3 marks)

b) Complete an ICE box for this problem, as if you were solving for the equilibrium concentrations for all species (1 marks)

12. If a gaseous mixture at 200°C contains 0.00917 M H_2 , 0.71 M N_2 , and 0.00018 M NH_3 , in what direction will a net reaction occur to reach equilibrium? (2 marks)



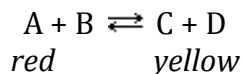
13. Use Le Chatelier's Principle to explain the color changes observed in Test Tubes 2 – 4 upon the addition of FeCl₃, KSCN, and KCl. (3 marks)



Test Tube	Stress Applied	Initial Color	Final Color
1	Control	Light yellow	--
2	AB added	Light yellow	Green
3	A added	Light yellow	Yellow
4	C added: decreases [A]	Light yellow	Green

14. Based on the colour changes observed in the hot water and cold water baths (shown in the table below), determine whether the forward reaction is endothermic or exothermic. Explain how you know. (2 marks)

Rewrite the equation with a simple energy term (“+ heat”) included on the appropriate side of the equation. You may find it easier if you begin by using only the terms “heat”, “red”, and “yellow” in your equation. (1 mark)



Temperature	Solution Colour
room temperature	Orange
hot water bath	Red
cold water bath	Yellow