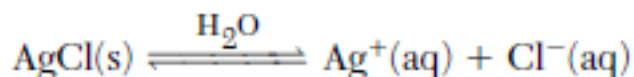


## Lechatelier'S Principle

- 1 For a reaction at equilibrium, which change can increase the rates of the forward and reverse reactions?
- (1) a decrease in the concentration of the reactants
  - (2) a decrease in the surface area of the products
  - (3) an increase in the temperature of the system
  - (4) an increase in the activation energy of the forward reaction

- 2 Which term identifies a factor that will shift a chemical equilibrium?
- (1) atomic radius
  - (2) catalyst
  - (3) decay mode
  - (4) temperature

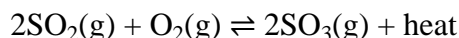
- 3 Given the equation representing a system at equilibrium:



When the concentration of  $\text{Cl}^-(\text{aq})$  is increased, the concentration of  $\text{Ag}^+(\text{aq})$

- (1) decreases, and the amount of  $\text{AgCl}(s)$  increases
- (2) decreases, and the amount of  $\text{AgCl}(s)$  decreases
- (3) increases, and the amount of  $\text{AgCl}(s)$  increases
- (4) increases, and the amount of  $\text{AgCl}(s)$  decreases

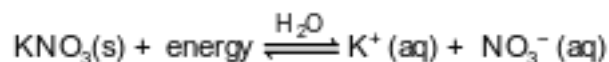
- 4 Given the equation representing a reaction at equilibrium:



Which change causes the equilibrium to shift to the right?

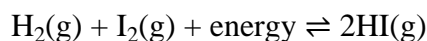
- (1) adding a catalyst
- (2) adding more  $\text{O}_2(\text{g})$
- (3) decreasing the pressure
- (4) increasing the temperature

- 5 Given the equation representing a system at equilibrium:



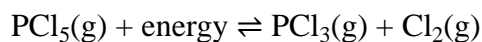
Which change causes the equilibrium to shift?

- (1) increasing pressure
  - (2) increasing temperature
  - (3) adding a noble gas
  - (4) adding a catalyst
- 6 Given the equation representing a chemical reaction at equilibrium in a sealed, rigid container:



When the concentration of  $\text{H}_2(\text{g})$  is increased by adding more hydrogen gas to the container at constant temperature, the equilibrium shifts

- (1) to the right, and the concentration of  $\text{HI}(\text{g})$  decreases
  - (2) to the right, and the concentration of  $\text{HI}(\text{g})$  increases
  - (3) to the left, and the concentration of  $\text{HI}(\text{g})$  decreases
  - (4) to the left, and the concentration of  $\text{HI}(\text{g})$  increases
- 7 Given the equation representing a system at equilibrium:

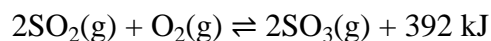


Which change will cause the equilibrium to shift to the right?

- (1) adding a catalyst
- (2) adding more  $\text{PCl}_3(\text{g})$
- (3) increasing the pressure
- (4) increasing the temperature

Base your answers to questions 8 on the information below.

Several steps are involved in the industrial production of sulfuric acid. One step involves the oxidation of sulfur dioxide gas to form sulfur trioxide gas. A catalyst is used to increase the rate of production of sulfur trioxide gas. In a rigid cylinder with a movable piston, this reaction reaches equilibrium, as represented by the equation below.



- 8 State, in terms of the concentration of  $\text{SO}_3(\text{g})$ , what occurs when more  $\text{O}_2(\text{g})$  is added to the reaction at equilibrium.

Base your answers to questions 9 on the information below and on your knowledge of chemistry.

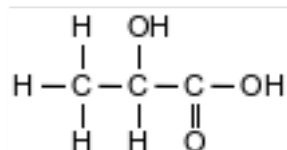
Common household bleach is an aqueous solution containing hypochlorite ions. A closed container of bleach is an equilibrium system represented by the equation below.



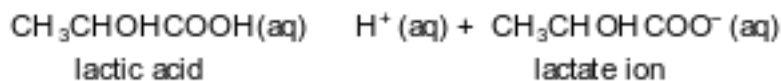
- 9 Explain why the container must be closed to maintain equilibrium.

Base your answers to questions 10 on the information below and on your knowledge of chemistry.

A student makes an aqueous solution of lactic acid. A formula for one form of lactic acid is shown below.



The solution is placed in a sealed flask to be used in a laboratory investigation. The equation below represents the lactic acid equilibrium system in the flask.



- 10 Explain, in terms of LeChatelier's principle, why increasing the concentration of  $\text{H}^+(\text{aq})$  increases the concentration of lactic acid.

Base your answers to questions 11 on the information below and on your knowledge of chemistry.

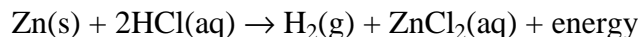
Nitrogen dioxide,  $\text{NO}_2$ , is a dark brown gas that is used to make nitric acid and to bleach flour. Nitrogen dioxide has a boiling point of 294 K at 101.3 kPa. In a rigid cylinder with a movable piston, nitrogen dioxide can be in equilibrium with colorless dinitrogen tetroxide,  $\text{N}_2\text{O}_4$ . This equilibrium is represented by the equation below.



- 11 State one stress, other than adding or removing  $\text{NO}_2(\text{g})$  or  $\text{N}_2\text{O}_4(\text{g})$ , that would increase the amount of the dark brown gas.

Base your answers to questions 12 on the information below and on your knowledge of chemistry.

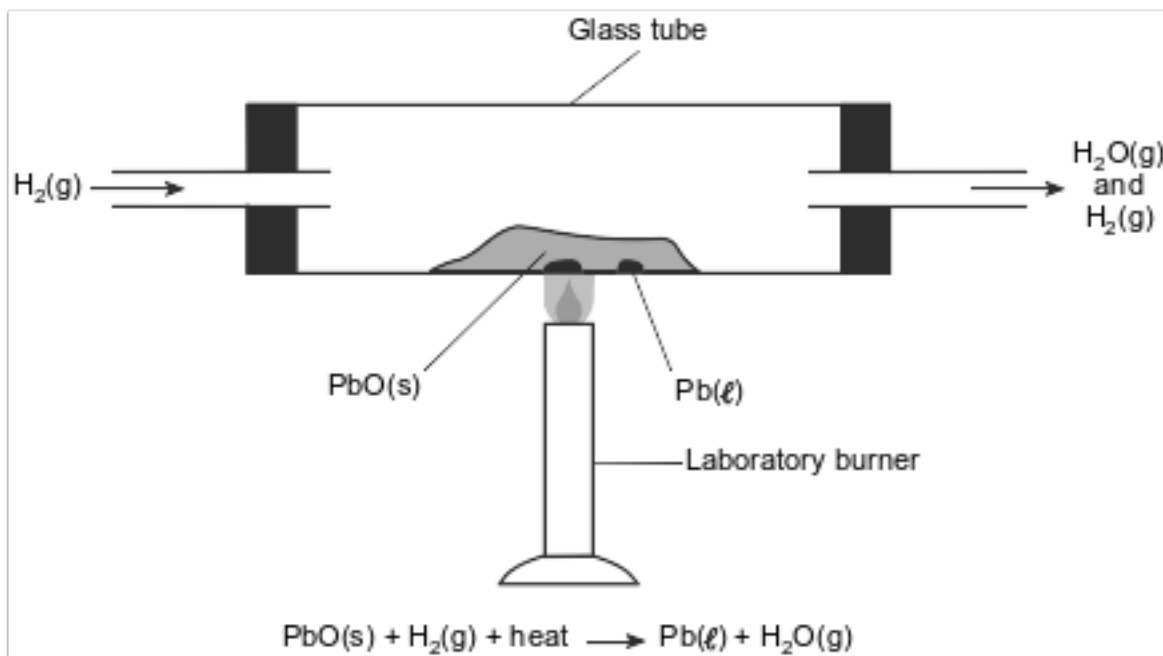
The balanced equation below represents the reaction between a 5.0-gram sample of zinc metal and a 0.5 M solution of hydrochloric acid. The reaction takes place in an open test tube at 298 K and 1 atm in a laboratory activity.



- 12 Explain why this reaction will not reach equilibrium.

Base your answers to questions 13 on the information below and on your knowledge of chemistry.

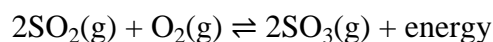
In a laboratory apparatus, a sample of lead(II) oxide reacts with hydrogen gas at high temperature. The products of this reaction are liquid lead and water vapor. As the reaction proceeds, water vapor and excess hydrogen gas leave the glass tube. The diagram and balanced equation below represent this reaction.



- 13 Explain why the reaction that occurs in this glass tube can not reach equilibrium.

Base your answers to questions 14 on the information below and on your knowledge of chemistry.

The equation below represents an equilibrium system of  $\text{SO}_2(\text{g})$ ,  $\text{O}_2(\text{g})$ , and  $\text{SO}_3(\text{g})$ . The reaction can be catalyzed by vanadium or platinum.

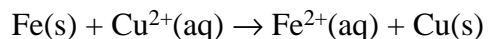


- 14 State how the equilibrium shifts when  $\text{SO}_3(\text{g})$  is removed from the system.

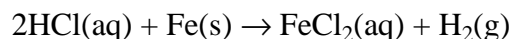
Base your answers to questions 15 on the information below and on your knowledge of chemistry.

Stamping an identification number into the steel frame of a bicycle compresses the crystal structure of the metal. If the number is filed off, there are scientific ways to reveal the number.

One method is to apply aqueous copper(II) chloride to the number area. The  $\text{Cu}^{2+}$  ions react with some iron atoms in the steel frame, producing copper atoms that show the pattern of the number. The ionic equation below represents this reaction.



Another method is to apply hydrochloric acid to the number area. The acid reacts with the iron, producing bubbles of hydrogen gas. The bubbles form faster where the metal was compressed, so the number becomes visible. The equation below represents this reaction.



- 15 Describe one change in the  $\text{HCl}(\text{aq})$  that will increase the rate at which hydrogen bubbles are produced when the acid is applied to the steel frame.

## Answer Keys

1 3

2 4

3 1

4 2

5 2

6 2

7 4

8 Allow 1 credit. Acceptable responses include, but are not limited to:

- The concentration of  $\text{SO}_3(\text{g})$  increases.

9 Allow 1 credit. Acceptable responses include, but are not limited to:

- The container must be closed so that no matter can enter or leave, thus disturbing the equilibrium.
- If the container is open,  $\text{Cl}_2$  gas escapes.
- to keep the concentrations of the reactants and products constant

10 Allow 1 credit. Acceptable responses include, but are not limited to:

- The stress of adding  $\text{H}^+$  ions shifts the equilibrium to the left, producing more lactic acid.
- Increasing the concentration of  $\text{H}^+(\text{aq})$  favors the reverse reaction.
- More  $\text{H}^+$  ions collide with lactate ions, shifting the equilibrium left.

11 Allow 1 credit. Acceptable responses include, but are not limited to:

- Increase the temperature.
- Add heat.
- Decrease the pressure.
- Increase the volume.

12 Allow 1 credit. Acceptable responses include, but are not limited to:

- The  $\text{H}_2(\text{g})$  can leave the open test tube.
- The reaction is driven to completion because a gas is released.
- Reaction not reversible.

13 Allow 1 credit. Acceptable responses include, but are not limited to:

- The glass tube is not a closed system.
- Gases are entering and leaving the system.

14 Allow 1 credit. Acceptable responses include, but are not limited to:

- The equilibrium will shift to favor the formation of  $\text{SO}_3$ .
- The rate of the forward reaction is greater than the rate of the reverse reaction.
- The equilibrium will shift to favor the forward reaction.
- The equilibrium will shift to the right.
- The concentrations of the reactants will decrease.

15 Allow 1 credit. Acceptable responses include, but are not limited to:

- Increase the concentration of the  $\text{HCl}(\text{aq})$ .
- Increase the temperature.