Equilibrium

1 Equilibrium can be reached by
(1) physical changes, only
(2) nuclear changes, only
(3) both physical changes and chemical changes
(4) both nuclear changes and chemical changes

2 A cube of iron at 20.°C is placed in contact with a cube of copper at 60.°C. Which statement describes the initial flow of heat between the cubes?
(1) Heat flows from the copper cube to the iron cube.
(2) Heat flows from the iron cube to the copper cube.
(3) Heat flows in both directions between the cubes.
(4) Heat does not flow between the cubes.

3 At which temperature will $Hg(\ell)$ and Hg(s) reach equilibrium in a closed system at 1.0 atmosphere?
(1) 234 K
(2) 273 K
(3) 373 K
(4) 630. K

4 Which equation represents a chemical equilibrium?
(1) $N_2(\ell) \rightleftharpoons N_2(g)$
(2) $2NO_2(g) \rightleftharpoons N_2O_4(g)$
(3) $CO_2(s) \rightleftharpoons CO_2(g)$
(4) $NH_3(\ell) \rightleftharpoons NH_3(g)$

5 Which changes can reach dynamic equilibrium?
(1) nuclear changes, only
(2) chemical changes, only
(3) nuclear and physical changes
(4) chemical and physical changes

6 An open flask is half filled with water at 25°C. Phase equilibrium can be reached after
(1) more water is added to the flask
(2) the flask is stoppered
(3) the temperature is decreased to 15°C
(4) the temperature is increased to 35°C

7 Which type of equilibrium exists in a sealed flask containing $Br_2(\ell)$ and $Br_2(g)$ at 298 K and 1.0 atm?
(1) static phase equilibrium
(2) static solution equilibrium
(3) dynamic phase equilibrium
(4) dynamic solution equilibrium

8 Some solid KNO_3 remains at the bottom of a stoppered flask containing a saturated $KNO_3(aq)$ solution at 22°C. Which statement explains why the contents of the flask are at equilibrium?
(1) The rate of dissolving is equal to the rate of crystallization.
(2) The rate of dissolving is greater than the rate of crystallization.
(3) The concentration of the solid is equal to the concentration of the solution.
(4) The concentration of the solid is greater than the concentration of the solution.

9 Which statement describes a reaction at equilibrium?
(1) The mass of the products must equal the mass of the reactants.
(2) The entropy of the reactants must equal the entropy of the products.
(3) The rate of formation of the products must equal the rate of formation of the reactants.
(4) The number of moles of the reactants must equal the number of moles of the products.

10 For a chemical system at equilibrium, the concentrations of both the reactants and the products must
(1) decrease
(2) increase
(3) be constant
(4) be equal

Base your answers to questions 11 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.

$Zn(s) + 2HCl(aq) \rightarrow H_2(g) + ZnCl_2(aq) + energy$

11 Explain why this reaction will not reach equilibrium.

12 State, in terms of the rates of the forward and reverse reactions, what occurs when dynamic equilibrium is reached in this system.

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

Methanol can be manufactured by a reaction that is reversible. In the reaction, carbon monoxide gas and hydrogen gas react using a catalyst. The equation below represents this system at equilibrium.

$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g) + energy$

13 Compare the rate of the forward reaction to the rate of the reverse reaction in this equilibrium system.

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

Nitrogen dioxide, 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, N_2O_4. This equilibrium is represented by the equation below.

$2NO_2(g) \rightleftharpoons N_2O_4(g) + 58\ kJ$

14 Compare the rate of the forward reaction to the rate of the reverse reaction when the system has reached equilibrium.

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

An equilibrium system in a sealed, rigid container is represented by the equation below.

$CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$

15 Compare the rate of the forward reaction to the rate of the reverse reaction at equilibrium.

Answer Keys

1 3

2 1

3 1

4 2

5 4

6 2

7 3

8 1

9 3

10 3

11 Allow 1 credit. Acceptable responses include, but are not limited to:
- The $H_2(g)$ can leave the open test tube.
- The reaction is driven to completion because a gas is released.
- Reaction not reversible.

12 Allow 1 credit. Acceptable responses include, but are not limited to:
- Dynamic equilibrium is reached when the rates of the forward and reverse reactions are equal.
- The rates in opposing directions are equal.
- The rates are the same.

13 Allow 1 credit. Acceptable responses include, but are not limited to:
- The rate of the forward reaction equals the rate of the reverse reaction.
- Both reactions occur at the same rate.

14 Allow 1 credit. Acceptable responses include, but are not limited to:
- The rate of the forward reaction is equal to the rate of the reverse reaction at equilibrium.
- The rates are the same.

15 Allow 1 credit. Acceptable responses include, but are not limited to:
- The rate of the forward reaction is equal to the rate of the reverse reaction.
- The rates are the same.