Name: Equilibrium Review Date:

1. Given the equation representing a reaction:

$$N_2O_4\,(g) \leftrightarrow 2NO_2(g)$$

Which statement describes this reaction at equilibrium?

(1) The concentration of $N_2O_4(g)$ must equal the concentration of $NO_2(g)$.
(2) The concentration of $N_2O_4(g)$ and the concentration of $NO_2(g)$ must be constant.
(3) The rate of the forward reaction is greater than the rate of the reverse reaction.
(4) The rate of the reverse reaction is greater than the rate of the forward reaction.

2. **Given the equation representing a phase change at equilibrium:**

$$C_2H_5OH(\ell) \leftrightarrow C_2H_5OH(g)$$

Which statement is true?

(1) The forward process proceeds faster than the reverse process.
(2) The reverse process proceeds faster than the forward process.
(3) The forward and reverse processes proceed at the same rate.
(4) The forward and reverse processes both stop.

3. **Which statement must be true for any chemical reaction at equilibrium?**

(1) The concentration of the products is greater than the concentration of the reactants.
(2) The concentration of the products is less than the concentration of the reactants.
(3) The concentration of the products and the concentration of the reactants are equal.
(4) The concentration of the products and the concentration of the reactants are constant.

4. **Given the reaction at equilibrium:**

$$H_2(g) + Br_2(g) \leftrightarrow 2\,HBr(g)$$

The rate of the forward reaction is

(1) greater than the rate of the reverse reaction
(2) less than the rate of the reverse reaction
(3) equal to the rate of the reverse reaction
(4) independent of the rate of the reverse reaction

5. **Which type or types of change, if any, can reach equilibrium?**

(1) a chemical change, only
(2) a physical change, only
(3) both a chemical and a physical change
(4) neither a chemical nor a physical change

6. **Which balanced equation represents a phase equilibrium?**

(1) $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$

(2) $2NO_2(g) \rightleftharpoons N_2O_4(g)$

(3) $Cl_2(g) \rightleftharpoons Cl_2(\ell)$

(4) $3O_2(g) \rightleftharpoons 2O_3(g)$

7. **The temperature at which the solid and liquid phases of matter exist in equilibrium is called its**

(1) melting point
(2) boiling point
(3) heat of fusion
(4) heat of vaporization

8. Given the phase equilibrium in a closed container:

$$H_2O(g) \leftrightarrow H_2O(\ell)$$

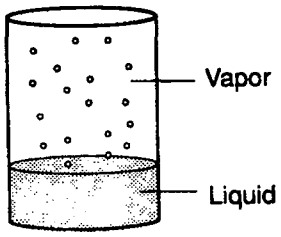
Compared to the rate of gas formation, the rate of liquid formation is

(1) slower (3) the same
(2) faster

9. The vapor pressure of a liquid at a given temperature is measured when the rate of evaporation of the liquid becomes

(1) less than the rate of condensation
(2) greater than the rate of condensation
(3) equal to the rate of condensation
(4) equal to a zero rate of condensation

10. A closed system is shown in the diagram below.



The rate of vapor formation at equilibrium is

(1) less than the rate of liquid formation
(2) greater than the rate of liquid formation
(3) equal to the rate of liquid formation

11. A sample of water in a sealed flask at 298 K is in equilibrium with its vapor. This is an example of

(1) chemical equilibrium
(2) phase equilibrium
(3) solution equilibrium
(4) static equilibrium

12. Ammonia is produced commercially by the Haber reaction:

$$N_2(g) + 3\ H_2(g) \leftrightarrow 2\ NH_3(g) + \text{heat}$$

The formation of ammonia is favored by

(1) an increase in pressure
(2) a decrease in pressure
(3) removal of $N_2(g)$
(4) removal of $H_2(g)$

13. Given the system at equilibrium:

$$H_2(g) + F_2(g) \leftrightarrow 2\ HF(g) + \text{heat}$$

Which change will *not* shift the point of equilibrium?

(1) changing the pressure
(2) changing the temperature
(3) changing the concentration of $H_2(g)$
(4) changing the concentration of $HF(g)$

14. Given the reaction at equilibrium:

$$4\ HCl(g) + O_2(g) \leftrightarrow 2\ Cl_2(g) + 2\ H_2O(g)$$

If the pressure on the system is increased, the concentration of $Cl_2(g)$ will

(1) decrease (3) remain the same
(2) increase

15. Given the closed system at equilibrium:

$$CO_2(g) \leftrightarrow CO_2(aq)$$

As the pressure on the system increases, the solubility of the $CO_2(g)$

(1) decreases (3) remains the same
(2) increases

16. Given the equilibrium reaction:

$$2\ SO_2(g) + O_2(g) \leftrightarrow 2\ SO_3(g) + \text{Heat}$$

When the pressure on the system in increased, the concentration of the SO_3 will
(1) decrease
(2) increase
(3) remain the same

17. Given the reaction at equilibrium:

$$2\ SO_2(g) + O_2(g) \leftrightarrow 2\ SO_3(g)$$

If the temperature remains constant, an increase in pressure will
(1) have no effect on the equilibrium
(2) shift the equilibrium to the right
(3) shift the equilibrium to the left
(4) change the value of the equilibrium constant

18. Given the reaction at equilibrium:

$$2\ A(g) + 3\ B(g) \leftrightarrow A_2B_3(g) + \text{heat}$$

Which change will not affect the equilibrium concentrations of $A(g)$, $B(g)$, and $A_2B_3(g)$?
(1) adding more $A(g)$
(2) adding a catalyst
(3) increasing the temperature
(4) increasing the pressure

19. The addition of a catalyst to a system at equilibrium will increase the rate of
(1) the forward reaction, only
(2) the reverse reaction, only
(3) both the forward and reverse reactions
(4) neither the forward nor reverse reaction

20. What will happen if a catalyst is added to the system at equilibrium?

$$A + B \leftrightarrow AB$$

(1) The equilibrium concentration of AB will increase.
(2) The equilibrium concentration of AB will decrease.
(3) The rates of the forward and reverse reactions will change.
(4) The equilibrium constant for the reaction will change.

21. Given the equation representing a reaction at equilibrium:

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) + \text{energy}$$

Which change causes the equilibrium to shift to the right?
(1) decreasing the concentration of $H_2(g)$
(2) decreasing the pressure
(3) increasing the concentration of $N_2(g)$
(4) increasing the temperature

22. Given the system at equilibrium:

$$2POCl_3(g) + \text{energy} \rightleftharpoons 2PCl_3(g) + O_2(g)$$

Which changes occur when $O_2(g)$ is added to this system?
(1) The equilibrium shifts to the right and the concentration of $PCl_3(g)$ increases.
(2) The equilibrium shifts to the right and the concentration of $PCl_3(g)$ decreases.
(3) The equilibrium shifts to the left and the concentration of $PCl_3(g)$ increases.
(4) The equilibrium shifts to the left and the concentration of $PCl_3(g)$ decreases.

23. Given the balanced equation representing a reaction:

$$2HCl(aq) + Na_2S_2O_3(aq) \rightarrow S(s) + H_2SO_3(aq) + 2NaCl(aq)$$

Decreasing the concentration of $Na_2S_2O_3(aq)$ decreases the rate of reaction because the
(1) activation energy decreases
(2) activation energy increases
(3) frequency of effective collisions decreases
(4) frequency of effective collisions increases

24. Given the reaction at equilibrium:

$$N_2(g) + 3H_2(g) \leftrightarrow 2NH_3(g) + 91.8kJ$$

What occurs when the concentration of $H_2(g)$ is increased?
(1) The rate of the forward reaction increases and the concentration of $N_2(g)$ decreases.
(2) The rate of the forward reaction decreases and the concentration of $N_2(g)$ increases.
(3) The rate of the forward reaction and the concentration of $N_2(g)$ both increase.
(4) The rate of the forward reaction and the concentration of $N_2(g)$ both decrease.

25. Given the reaction at equilibrium:

$$N_2(g) + O_2(g) + \text{energy} \leftrightarrow 2\ NO(g)$$

Which change will result in a *decrease* in the amount of NO(g) formed?
(1) decreasing the pressure
(2) decreasing the concentration of $N_2(g)$
(3) increasing the concentration of $O_2(g)$
(4) increasing the temperature

26. Given the solution at equilibrium:

$$PbI_2(s) \leftrightarrow Pb^{2+}(aq) + 2I^-(aq)$$

The addition of which nitrate salt will cause a decrease in the concentration of $I^-(aq)$?
(1) $Pb(NO_3)_2$
(2) $Ca(NO_3)_2$
(3) $LiNO_3$
(4) KNO_3

27. Given the equation representing a reaction at equilibrium:

$$H_2(g) + I_2(g) + \text{heat} \leftrightarrow 2HI(g)$$

Which change favors the reverse reaction?
(1) decreasing the concentration of HI(g)
(2) decreasing the temperature
(3) increasing the concentration of $I_2(g)$
(4) increasing the pressure

28. Given the system at equilibrium:

$$N_2O_4(g) + 58.1\ kJ \leftrightarrow 2\ NO_2(g)$$

What will be the result of an increase in temperature at constant pressure?
(1) The equilibrium will shift to the left, and the concentration of $NO_2(g)$ will decrease.
(2) The equilibrium will shift to the left, and the concentration of $NO_2(g)$ will increase.
(3) The equilibrium will shift to the right, and the concentration of $NO_2(g)$ will decrease.
(4) The equilibrium will shift to the right, and the concentration of $NO_2(g)$ will increase.

29. Given the equilibrium reaction in a closed system:

$$H_2(g) + I_2(g) + \text{heat} \leftrightarrow 2\ HI(g)$$

What will be the result of an increase in temperature?

(1) The equilibrium will shift to the left and $[H_2]$ will increase.
(2) The equilibrium will shift to the left and $[H_2]$ will decrease.
(3) The equilibrium will shift to the right and [HI] will increase.
(4) The equilibrium will shift to the right and [HI] will decrease.

30. What occurs when the temperature is increased in a system at equilibrium at constant pressure?

(1) The rate of the forward reaction increases, and the rate of the reverse reaction decreases.
(2) The rate of the forward reaction decreases, and the rate of the reverse reaction increases.
(3) The rate of the endothermic reaction increases.
(4) The rate of the exothermic reaction decreases.

31. Given the reaction at equilibrium:

$$C_2(g) + D_2(g) \leftrightarrow 2\ CD(g) + \text{energy}$$

Which change will cause the equilibrium to shift?

(1) increase in pressure
(2) increase in volume
(3) addition of heat
(4) addition of a catalyst

32. Given the reaction for the Haber process:

$$N_2 + 3\ H_2 \leftrightarrow 2\ NH_3 + \text{heat}$$

The temperature of the reaction is raised in order to

(1) increase the percent yield of nitrogen
(2) increase the rate of formation of ammonia
(3) affect the forward reaction rate most
(4) affect the reverse reaction rate least

33. Given the system at equilibrium:

$$PbCO_3(s) \leftrightarrow Pb^{2+}(aq) + CO_3^{2-}(aq)$$

How will the addition of $Na_2CO_3(aq)$ affect $[Pb^{2+}](aq)$ and the mass of $PbCO_3(s)$?

(1) $[Pb^{2+}](aq)$ will decrease and the mass of $PbCO_3(s)$ Will decrease.
(2) $[Pb^{2+}](aq)$ will decrease and the mass of $PbCO_3(s)$ will increase.
(3) $[Pb^{2+}](aq)$ will increase and the mass of $PbCO_3(s)$ will decrease.
(4) $[Pb^{2+}](aq)$ will increase and the mass of $PbCO_3(s)$ will increase.

34. Given the reaction at equilibrium:

$$AgBr(s) \leftrightarrow Ag^+(aq) + Br^-(aq)$$

Which change occurs when KBr(s) is dissolved in the reaction mixture?

(1) The amount of AgBr(s) decreases.
(2) The amount of AgBr(s) remains the same.
(3) The concentration of $Ag^+(aq)$ decreases.
(4) The concentration of $Ag^+(aq)$ remains the same.

35. Given the solution at equilibrium:

$CaSO_4(s) \leftrightarrow Ca^{2+}(aq) + SO_4^{2-}(aq)$

When Na_2SO_4 is added to the system, how will the equilibrium shift?

(1) The amount of $CaSO_4(s)$ will decrease, and the concentration of $Ca^{2+}(aq)$ will decrease.

(2) The amount of $CaSO_4(s)$ will decrease, and the concentration of $Ca^{2+}(aq)$ will increase.

(3) The amount of $CaSO_4(s)$ will increase, and the concentration of $Ca^{2+}(aq)$ will decrease.

(4) The amount of $CaSO_4(s)$ Will increase, and the concentration of $Ca^{2+}(aq)$ will increase.

Equilibrium Review
Answer Key
[New Exam]

1. 2
2. 3
3. 4
4. 3
5. 3
6. 3
7. 1
8. 3
9. 3
10. 3
11. 2
12. 1
13. 1
14. 2
15. 2
16. 2
17. 2
18. 2
19. 3
20. 3
21. 3
22. 4
23. 3
24. 1
25. 2
26. 1
27. 2
28. 4
29. 3
30. 3
31. 3
32. 2
33. 2
34. 3
35. 3