Name Key Date Class H. Chem

Chapter 22

STUDY GUIDE

22.2 CHEMICAL EQUILIBRIUM

For items 1-8, underline the term inside the parentheses that makes each statement true.

1. At equilibrium, the rate of the forward reaction is (equal to, greater than) the rate of the reverse reaction.

2. The equilibrium constant for a given reaction at a given temperature is the (product, quotient) of the specific rate constant for the forward reaction and the specific rate constant for the reverse reaction.

3. The exponents used in the expression for the equilibrium constant are the (subscripts, coefficients) of the reactants and products.

4. If a reaction tends to go toward completion, the rate of the forward reaction is (equal to, greater than) the rate of the reverse reaction before equilibrium is reached.

5. If $K_{eq} = 1.2 \times 10^{-5}$, the concentration of the reactants is (greater than, less than) the concentration of the products at equilibrium. Keq < 1 means reactants are favored

6. At temperature T_1, K_{eq} for a certain reaction is 0.239. At temperature T_2, K_{eq} for the same reaction is 4.7. By changing the temperature from T_1 to T_2, the equilibrium will shift in favor of the (reactants, products). Keq > 1 means products are favored

7. If the reaction $H_2(g) + Cl_2(g) \rightleftarrows 2HCl(g)$ + *heat* is at equilibrium, a decrease in (volume, temperature) will produce a shift in equilibrium toward the right.

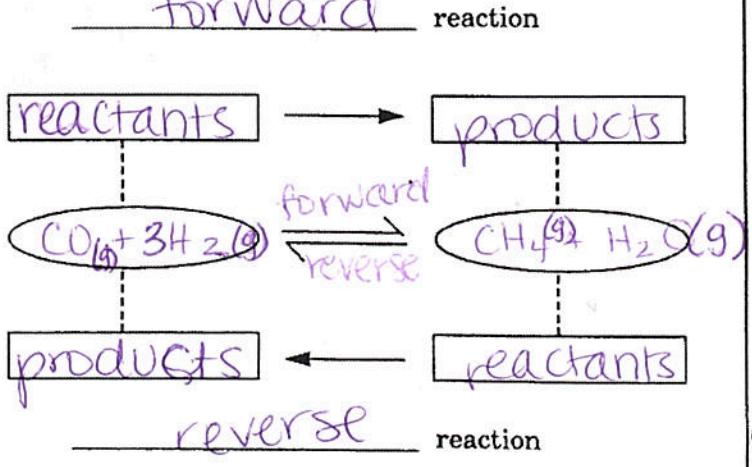
8. An increase in pressure on the system $2CO_2(g) \rightleftarrows 2CO(g) + O_2(g)$ at equilibrium results in an equilibrium shift toward the (left, right).

Answer or complete each of the following items.

9. What factors can affect the equilibrium of a reaction?

concentration, temperature, pressure

10. A reversible one-step reaction occurs between carbon monoxide gas, CO, and hydrogen gas, H_2, to produce methane gas, CH_4, and gaseous water. Using this information, fill in the diagram according to the following guidelines:
    a. Within the ovals, write the balanced equation for the reaction.
    b. Label the forward and reverse reactions on the lines provided.
    c. In the rectangles, write the words *reactants* or *products*, as appropriate, to represent both the forward and reverse reactions.



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11. Write the expression for the equilibrium constant for the reaction in question 10.

$K_{eq} = \frac{[CH_4] \times [H_2O]}{[CO] \times [H_2]^3}$

12. If temperature and pressure of the reaction in question 10 are kept constant, but the concentration of each of the substances is halved,

a. how does the rate of the forward reaction change?

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b. how does the rate of the reverse reaction change?

c. what would be the net change in the relative amounts of reactants and products?

13. In the reaction in question 10, if the volume of the reaction vessel and temperature are kept constant and the pressure on the system is increased,

a. the concentrations of which substances would be affected? all

b. in which direction will the equilibrium shift? right

c. which substance(s) will show an increase in concentration when equilibrium is reestablished?

CH_4, H_2O

14. Consider the equilibrium equation for the reaction: $4HCl(g) + O_2(g) + heat \rightleftarrows 2Cl_2(g) + 2H_2O(g)$

a. If the temperature is increased, the reaction will favor the formation of products. (shift towards right)

b. Which reaction requires an input of energy? forward rxn endothermic

15. In the Haber process, which involves the reaction $N_2(g) + 3H_2(g) \rightleftarrows 2NH_3 + energy$,

a. why is NH_3 removed as it is formed?

shifts equilibrium to right to keep making product

b. why is the use of a catalyst considered one of the optimum conditions for this process?

speeds up the reaction.

c. what is the effect on the relative amounts of product and reactant if the catalyst is removed?

none

A catalyst only speeds up the rate of forward + reverse rxn. It does not affect equilibrium.

16. Given $K_{eq} = \frac{[NO]^4[H_2O]^6}{[NH_3]^4[O_2]^5}$

a. Write the chemical equation for the reversible reaction having the given K_{eq}.

$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g)$

b. At a certain temperature the concentrations of NO and NH_3 are equal, and the concentration of H_2O and O_2 are 2.0*M* and 3.0*M* respectively. What is the value of K_{eq} at this temperature?

$K_{eq} = \frac{[NO]^4 \times [H_2O]^6}{[NH_3]^4 \times [O_2]^5} = \frac{(2.0)^6}{(3.0)^5} = \frac{64}{243} = \boxed{0.26}$

cancel out b/c equal