Equilibrium Review Worksheet Name Answer Key Date______ Per___

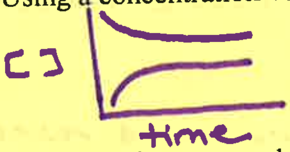
1. Give three factors that would speed up the rate of the reaction given below, and EXPLAIN how those factors alter the rate. $2Mg(s) + O_2(g) \leftrightarrow 2MgO(s)$

   a. Catalyst – speeds up rate of reaction but does not change Keq

   b. Stir it! – creates more collisions between particles

   c. crush/increase surface area – more S.A. means more reactive sites

2. Using a concentration vs time graph, describe the rate of an equilibrium reaction over time.



   reaction rates are variable at first but when they remain constant, equilibrium is reached. the concentrations of substance can be different.

3. Describe what you could do if you wanted to shift the equilibrium of the following reaction towards products. (At least 4 things!)

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

   a. increase [reactant]

   b. remove heat

   c. remove SO_3

   d. increase pressure (gases will move to the side w/fewer moles)

4. Write the equilibrium constant expression for the following reaction: $2A \leftrightarrow 2C + 3D$

$$K_{eq} = \frac{[C]^2[D]^3}{[A]^2}$$

5. You have 25.0 grams of sodium hydroxide and you dissolve it in 457 mL of water. What is its concentration?

$$25.0\,g\,NaOH \times \frac{1\,mol\,NaOH}{40.0\,g\,NaOH} = 0.625\,mol\,NaOH \qquad \frac{0.625\,mol}{.457\,L} = 1.37\,M\,NaOH$$

6. Using the equations and equilibrium constant equation from #4 calculate the equilibrium constant if the [A]=0.1077 mol/L, [C]= 0.0004104 mol/L [D]= 0.0004104 mol/L. Are products or reactants favored at equilibrium?

$$K_{eq} = \frac{[.0004104]^2[0.0004104]^3}{[0.1077]^2} = 1.004\times10^{-15}$$

   reactant favored

7. Write the chemical equilibrium expression for the following equations. Then use the given equilibrium constant to determine if the forward or reverse reaction is favored.

   $K_{eq} > 1$ product favored
   $K_{eq} < 1$ reactant favored

   a. $N_2O_4(g) \leftrightarrow 2NO_2(g)$ K=0.1 $\frac{[NO_2]^2}{[N_2O_4]}$

      reverse

   b. $NH_4OH(aq) \leftrightarrow NH_4^+(aq) + OH^-(aq)$ $K=2\times10^{-5}$ $\frac{[NH_4^+][OH^-]}{[NH_4OH]}$

      reverse

   c. $H_2(g) + I_2(g) \leftrightarrow 2HI(g)$ K=54.0 $\frac{[HI]^2}{[H_2][I_2]}$

      forward

8. Consider the following equilibrium equation: $CH_3OH(g) + 101\,kJ \leftrightarrow CO(g) + 2H_2(g)$

   a. Increasing the concentration of CO will

      shift rxn toward reactants

   b. Increasing the pressure of the system will

      shift rxn toward reactants

   c. Increasing the volume of the container for the reaction will

      shift rxn toward products

d. Placing the reaction vessel in a water bath to remove heat from the reaction will
Shift toward reactants

e. Removing the hydrogen gas through a secondary reaction will
Shift toward products

f. Adding a catalyst will
Speed up reaction but not affect equilibrium

9. Will raising the temperature of an equilibrium system favor exothermic reactions, endothermic reactions, or all reactions? Explain!

↑ heat to endothermic rxns produces more products

↑ heat to exothermic rxns produces more reactants

10. How do you know a reaction has reached equilibrium? Discuss the rates of the forward and reverse reactions as well as the concentration of reactants and products in your answer.

equilibrium is reached when the forward and reverse reactions are equal. The concentrations of reactants and products are not the same, but experience no net change.

11. Use this reaction for each of the following: $2NO_2\ (g) + O_2\ (g) \leftrightarrow 2NO_3\ (g)$

a. Write the expression for the equilibrium constant.

$$K_{eq} = \frac{[NO_3]^2}{[NO_2]^2[O_2]}$$

b. If gas concentrations are as follows, 2.10 M NO_2, 1.75 M O_2, and 1.00 M NO_3, calculate K_{eq}

$$K_{eq} = \frac{[1]^2}{[2.10]^2[1.75]} = 0.130$$

c. Using Keq from part b, are the reactants or the products favored?
reactants are favored (less than 1)

d. Using Keq from part c, calculate $[NO_3]$ if $[NO_2] = [O_2] = 4.3 \times 10^{-6}$

$$0.130 = \frac{[NO_3]^2}{[4.3\times10^{-6}]^2[4.3\times10^{-6}]} = \sqrt{.130\,(4.3\times10^{-6})^3} = 3.2\times10^{-9}M$$

e. A reaction has not yet reached equilibrium. Using the following concentrations, calculate the reaction quotient (Q) and predict which direction the reaction will shift to reach equilibrium. [1.20] M NO_2, [0.85] M O_2, and [3.00] M NO_3

$$Q = \frac{[3]^2}{[1.2]^2[.85]} = 7.35$$

shifts to reactants (left)

12. Use the following acidity constants to help answer the questions below:
$K_a(HC_2H_3O_2) = 1.8 \times 10^{-5}$; $K_a(HCN) = 4.9 \times 10^{-10}$; $K_a(HCOOH) = 1.7 \times 10^{-4}$

Which of the three acids is the weakest? HCN (smallest K_a)

13. Consider the reaction: $CH_3NH_2(aq) + H_2O(l) \leftrightarrow CH_3NH_3^+(aq) + OH^-(aq)$ where $K_b = 4.4 \times 10^{-4}$. To a solution formed from the addition of 2.0 mol CH_3NH_2 to 1.0 L of H_2O is added 1.0 mol of KOH (assume no volume change on addition of solutes). What is the concentration of $CH_3NH_3^+$ at equilibrium?

A) 3.2 x 10-2 M
B) 2.2 x 10-4 M
C) 2.0 x 10-3 M
D) 8.8 x 10-4 M
E) None of these

With K_a and K_b we can ignore H_2O

$$K_b = \frac{[CH_3NH_3^+][OH^-]}{[CH_3NH_2]} \qquad 4.4\times10^{-4} = \frac{[CH_3NH_3^+][1]}{[2]}$$

$$[CH_3NH_3^+] = 8.8\times10^{-4}M$$

14. When CaF_2 dissolves, it dissociates like this: $CaF_2(s) \leftrightarrow Ca^{2+}(aq) + 2F^-(aq)$ and the Ksp of CaF_2 is 3.92×10^{-11}
What is the Ksp expression?

$$3.92\times10^{-11} = [Ca^{2+}][F^-]^2$$

15. Calculate the equilibrium concentration of N_2O_5 in the reaction: $2N_2O_5\ (soln) \Leftrightarrow 4NO_2\ (g) + O_2(g)$ where K_{eq} @45°C is 2800 and the equilibrium concentration of O_2 is 1.0 M. (Assume no products to start.)

$$K_{eq} = \frac{[NO_2]^4[O_2]}{[N_2O_5]^2} \qquad 2800 = \frac{[4]^4[1]}{[N_2O_5]^2} \qquad \sqrt{[N_2O_5]^2} = \sqrt{\frac{[4]^4[1]}{2800}} \qquad [N_2O_5] = 0.30M$$