Name: _____ **Class:** _____ **Date:** _____ **ID: A**

CHEM II Rate of Reactions and Equilibrium

Multiple Choice
Identify the choice that best completes the statement or answers the question. Please show all work for full credit.

____ 1. Write a balanced reaction for which the following rate relationships are true.

$$\text{Rate} = -\frac{1}{2}\frac{\Delta[N_2O_5]}{\Delta t} = \frac{1}{4}\frac{\Delta[NO_2]}{\Delta t} = \frac{\Delta[O_2]}{\Delta t}$$

a. $2\ N_2O_5 \rightarrow 4\ NO_2 + O_2$
b. $4\ NO_2 + O_2 \rightarrow 2\ N_2O_5$
c. $2\ N_2O_5 \rightarrow NO_2 + 4\ O_2$
d. $\frac{1}{4}\ NO_2 + O_2 \rightarrow \frac{1}{2}\ N_2O_5$
e. $\frac{1}{2}\ N_2O_5 \rightarrow \frac{1}{4}\ NO_2 + O_2$

____ 2. Give the characteristic of a first-order reaction having only one reactant.
a. The rate of the reaction is not proportional to the concentration of the reactant.
b. The rate of the reaction is proportional to the square of the concentration of the reactant.
c. The rate of the reaction is proportional to the square root of the concentration of the reactant.
d. The rate of the reaction is proportional to the natural logarithm of the concentration of the reactant.
e. The rate of the reaction is directly proportional to the concentration of the reactant.

____ 3. A rate is equal to 0.0200 M/s. If [A] = 0.100 M and rate = $k[A]^0$, what is the new rate if the concentration of [A] is increased to 0.200 M?
a. 0.0200 M/s
b. 0.0400 M/s
c. 0.0600 M/s
d. 0.0800 M/s
e. 0.100 M/s

____ 4. A rate is equal to 0.0200 M/s. If [A] = 0.100 M and rate = $k[A]^0[B]^2$, what is the new rate if the concentration of [A] is increased to 0.200 M?
a. 0.0200 M/s
b. 0.0400 M/s
c. 0.0600 M/s
d. 0.0800 M/s
e. 0.100 M/s

____ 5. What data should be plotted to show that experimental concentration data fits a first-order reaction?
a. 1/[reactant] vs. time
b. [reactant] vs. time
c. ln[reactant] vs. time
d. ln(k) vs. 1/T
e. ln(k) vs. E_a

____ 6. Identify the rate-determining step.
a. the slowest step
b. the faster step
c. the fast step
d. always the last step
e. always the second step

____ 7. Given the following balanced equation, determine the rate of reaction with respect to $[SO_3]$.

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

a. $\text{Rate} = -\frac{1}{2}\frac{\Delta[SO_3]}{Dt}$

b. $\text{Rate} = +\frac{1}{2}\frac{\Delta[SO_3]}{\Delta t}$

c. $\text{Rate} = +\frac{\Delta[SO_3]}{Dt}$

d. $\text{Rate} = -\frac{3\,\Delta[SO_3]}{\Delta t}$

e. It is not possible to determine without more information.

____ 8. Define *dynamic equilibrium*.
a. no reactants react
b. no products are formed
c. the rate of the forward reaction is faster than the rate of the reverse reaction
d. the rate of the reverse reaction is faster than the rate of the forward reaction
e. the rate of the forward reaction equals the rate of the reverse reaction

____ 9. Which of the following statements is FALSE?
a. When $K >> 1$, the forward reaction is favored and essentially goes to completion.
b. When $K << 1$, the reverse reaction is favored and the forward reaction does not proceed to a great extent.
c. When $K \approx 1$, neither the forward or reverse reaction is strongly favored, and about the same amount of reactants and products exist at equilibrium.
d. $K >> 1$ implies that the reaction is very fast at producing products.
e. None of the above.

____ 10. Give the direction of the reaction, if $K >> 1$.
a. The forward reaction is favored.
b. The reverse reaction is favored.
c. Neither direction is favored.
d. If the temperature is raised, then the forward reaction is favored.
e. If the temperature is raised, then the reverse reaction is favored.

____ 11. Give the direction of the reaction, if $K << 1$.
a. The forward reaction is favored.
b. The reverse reaction is favored.
c. Neither direction is favored.
d. If the temperature is raised, then the forward reaction is favored.
e. If the temperature is raised, then the reverse reaction is favored.

____ 12. Give the direction of the reaction, if $K \approx 1$.
a. The forward reaction is favored.
b. The reverse reaction is favored.
c. Neither direction is favored.
d. If the temperature is raised, then the forward reaction is favored.
e. If the temperature is raised, then the reverse reaction is favored.

____ 13. Express the equilibrium constant for the following reaction.

$$CH_4(g) + 2\ O_2(g) \Leftrightarrow CO_2(g) + 2\ H_2O(g)$$

a. $K = \dfrac{[CH_4][O_2]}{[CO_2][H_2O]}$

b. $K = \dfrac{[CH_4][2O_2]^2}{[CO_2][2H_2O]^2}$

c. $K = \dfrac{[CO_2][H_2O]^2}{[CH_4][O_2]^2}$

d. $K = \dfrac{[CO_2][2H_2O]^2}{[CH_4][2O_2]^2}$

e. $K = \dfrac{[CH_4][O_2]^2}{[CO_2][H_2O]^2}$

____ 14. The equilibrium constant is given for one of the reactions below. Determine the value of the missing equilibrium constant.

$H_2(g) + Br_2(g) \rightleftharpoons HBr(g)$ $K_c = 3.8 \times 10^4$
$HBr(g) \rightleftharpoons H_2(g) + Br_2(g)$ $K_c = \ ?$

a. 1.9×10^4
b. 5.3×10^{-5}
c. 2.6×10^{-5}
d. 6.4×10^{-4}
e. 1.6×10^3

____ 15. The equilibrium constant is given for two of the reactions below. Determine the value of the missing equilibrium constant.

$A(g) + B(g) \rightleftharpoons AB(g)$ $K_c = 0.24$
$AB(g) + A(g) \rightleftharpoons A_2B(g)$ $K_c = 3.8$
$2\ A(g) + B(g) \rightleftharpoons A_2B(g)$ $K_c = ?$

a. 4.0
b. 0.91
c. 3.6
d. 16
e. 0.063

____ 16. Express the equilibrium constant for the following reaction.

$Pb(NO_3)_2(aq) + 2\ NaI(aq) \rightleftharpoons PbI_2(s) + 2\ NaNO_3(aq)$

a. $K = \dfrac{[2NaNO_3]^2[PbI_2]}{[Pb(NO_3)_2][2NaI]^2}$

b. $K = \dfrac{[2NaNO_3]^2}{[Pb(NO_3)_2][2NaI]^2}$

c. $K = \dfrac{[NaNO_3]^2[PbI_2]}{[Pb(NO_3)_2][NaI]^2}$

d. $K = \dfrac{[NaNO_3]^2}{[Pb(NO_3)_2][NaI]^2}$

e. $K = \dfrac{[Pb(NO_3)_2][NaI]^2}{[NaNO_3]^2}$

____ 17. Express the equilibrium constant for the following reaction.

$$4\ Al(s) + 3\ O_2(g) \rightleftharpoons 2\ Al_2O_3(s)$$

a. $K = \dfrac{[Al_2O_3]^2}{[O_2]^3[Al]^4}$

b. $K = \dfrac{1}{[3O_2]^3}$

c. $K = \dfrac{1}{[O_2]^3}$

d. $K = [O_2]3$

e. $K = [3O_2]3$

____ 18. Determine the value of K_c for the following reaction if the equilibrium concentrations are as follows: $[N_2]_{eq} = 3.6$ M, $[O_2]_{eq} = 4.1$ M, $[N_2O]_{eq} = 3.3 \times 10^{-18}$ M.

$$2\ N_2(g) + O_2(g) \rightleftharpoons 2\ N_2O(g)$$

a. 2.2×10^{-19}

b. 4.5×10^{18}

c. 2.0×10^{-37}

d. 5.0×10^{36}

e. 4.9×10^{-17}

____ 19. Determine the value of K_c for the following reaction if the equilibrium concentrations are as follows: $[N_2]_{eq} = 1.5$ M, $[H_2]_{eq} = 1.1$ M, $[NH_3]_{eq} = 0.47$ M.

$$N_2(g) + 3\ H_2(g) \rightleftharpoons 2\ NH_3(g)$$

a. 3.5

b. 0.28

c. 9.1

d. 0.11

e. 0.78

____ 20. Calculate the value of $[N_2]_{eq}$ if $[H_2]_{eq} = 2.0$ M, $[NH_3]_{eq} = 0.5$ M, and $K_c = 2$.

$$N_2(g) + 3\ H_2(g) \rightleftharpoons 2\ NH_3(g)$$

a. 0.016 M

b. 0.031 M

c. 0.062 M

d. 0.40 M

e. 62.5 M

____ 21. Consider the following reaction, equilibrium concentrations, and equilibrium constant at a particular temperature. Determine the equilibrium concentration of $H_2O(g)$.

$$C_2H_4(g) + H_2O(g) \rightleftharpoons C_2H_5OH(g) \quad K_c = 9.0 \times 10^3$$

$[C_2H4]_{eq} = 0.015$ M $\qquad$ $[C_2H_5OH]_{eq} = 1.69$ M

a. 9.9×10^{-7} M
b. 80. M
c. 1.0 M
d. 1.68 M
e. 0.013 M

____ 22. Consider the following reaction:

$$Xe(g) + 2\ F_2(g) \rightleftharpoons XeF_4(g)$$

A reaction mixture initially contains 2.24 atm Xe and 4.27 atm F_2. If the equilibrium pressure of Xe is 0.34 atm, find the equilibrium constant (K_p) for the reaction.

a. 25
b. 0.12
c. 0.99
d. 8.3
e. 0.040

____ 23. Consider the following reaction:

$$CH_4(g) + 2\ H_2S(g) \rightleftharpoons CS_2(g) + 4\ H_2(g)$$

A reaction mixture initially contains 0.50 M CH_4 and 0.75 M H_2S. If the equilibrium concentration of H_2 is 0.44 M, find the equilibrium constant (K_c) for the reaction.

a. 0.23
b. 0.038
c. 2.9
d. 10.
e. 0.34

____ 24. Consider the following reaction:

$$CO_2(g) + C(graphite) \rightleftharpoons 2\ CO(g)$$

A reaction mixture initially contains 0.56 atm CO_2 and 0.32 atm CO. Determine the equilibrium pressure of CO if K_p for the reaction at this temperature is 2.25.

a. 0.83 atm
b. 0.31 atm
c. 0.26 atm
d. 0.58 atm
e. 0.42 atm

____ 25. Define *Le Chatelier's Principle*.

a. When a chemical system at equilibrium is disturbed, the system shifts in a direction that maximizes the disturbance.
b. A system will always change if the pressure changes.
c. When a chemical system at equilibrium is disturbed, the system shifts in a direction that equals the disturbance.
d. When a chemical system at equilibrium is disturbed, the system shifts in a direction that minimizes the disturbance.
e. A system will always change if the volume changes.

____ 26. Consider the following reaction at equilibrium. What will happen if FeS_2 is added to the reaction?

$$4\ FeS_2(s) + 11\ O_2(g) \rightleftharpoons 2\ Fe_2O_3(s) + 8\ SO_2(g)$$

a. The equilibrium constant will increase.
b. The equilibrium will change in the direction of the reactants.
c. The equilibrium will change in the direction of the products.
d. No change in equilibrium is observed.
e. The equilibrium constant will decrease.

____ 27. Consider the following reaction at equilibrium. What will happen if O_2 is added to the reaction?

$$4\ FeS_2(s) + 11\ O_2(g) \rightleftharpoons 2\ Fe_2O_3(s) + 8\ SO_2(g)$$

a. The equilibrium constant will increase.
b. The equilibrium will change in the direction of the reactants.
c. The equilibrium will change in the direction of the products.
d. No change in equilibrium is observed.
e. The equilibrium constant will decrease.

____ 28. Consider the following reaction at equilibrium. What will happen if the pressure **increased**?

$$4\ FeS_2(s) + 11\ O_2(g) \rightleftharpoons 2\ Fe_2O_3(s) + 8\ SO_2(g)$$

a. The equilibrium constant will increase.
b. The equilibrium will change in the direction of the reactants.
c. The equilibrium will change in the direction of the products.
d. No change in equilibrium is observed.
e. The equilibrium constant will decrease.

____ 29. Consider the following reaction at equilibrium. What will happen if the volume **increased**?

$$4\ FeS_2(s) + 11\ O_2(g) \rightleftharpoons 2\ Fe_2O_3(s) + 8\ SO_2(g)$$

a. The equilibrium constant will increase.
b. The equilibrium will change in the direction of the reactants.
c. The equilibrium will change in the direction of the products.
d. No change in equilibrium is observed.
e. The equilibrium constant will decrease.

____ 30. The following reaction is exothermic. Which change will shift the equilibrium to the left?

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

a. raising the temperature
b. adding SO_3
c. removing O_2
d. all of the above
e. none of the above

____ 31. The following reaction is exothermic. Which change will shift the equilibrium to the left?

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

a. raising the temperature
b. decrease pressure
c. increase volume
d. all of the above
e. none of the above

____ 32. Consider the following reaction at equilibrium. What effect will adding more SO_3 have on the system?

$$SO_2(g) + NO_2(g) \rightleftharpoons SO_3(g) + NO(g)$$

a. The reaction will shift in the direction of products.
b. The reaction will shift to decrease the pressure.
c. No change will occur since SO_3 is not included in the equilibrium expression.
d. The reaction will shift in the direction of reactants.
e. The equilibrium constant will decrease.

____ 33. Consider the following reaction at equilibrium. What effect will removing NO_2 have on the system?

$$SO_2(g) + NO_2(g) \rightleftharpoons SO_3(g) + NO(g)$$

a. The reaction will shift in the direction of products.
b. The reaction will shift to decrease the pressure.
c. No change will occur since SO_3 is not included in the equilibrium expression.
d. The reaction will shift in the direction of reactants.
e. The equilibrium constant will decrease.

____ 34. Consider the following reaction at equilibrium. What effect will **increasing** the volume of the reaction mixture have on the system?

$$2\ H_2S(g) + 3\ O_2(g) \rightleftharpoons 2\ H_2O(g) + 2\ SO_2(g)$$

a. The reaction will shift to the right in the direction of products.
b. No effect will be observed.
c. The reaction will shift to the left in the direction of reactants.
d. The equilibrium constant will decrease.
e. The equilibrium constant will increase.

____ 35. Consider the following reaction at equilibrium. What effect will **reducing** the volume of the reaction mixture have on the system?

$$CuS(s) + O_2(g) \rightleftharpoons Cu(s) + SO_2(g)$$

a. The equilibrium constant will decrease.
b. No effect will be observed.
c. The reaction will shift to the right in the direction of products.
d. The equilibrium constant will increase.
e. The reaction will shift to the left in the direction of reactants.