Solutions for Practice Exam 1

1. Consider the reaction
   \[ \text{S}_2\text{O}_8^{2-} + 3 \text{I}^- \rightarrow 2\text{SO}_4^{2-} + \text{I}_3^- \]

   which one of the following rate expressions would give the same value as the rate of disappearance of \( \text{S}_2\text{O}_8^{2-} \)?

   b. rate = \(-1/3(\Delta[I^-]/\Delta t)\)

2. The exponents (= orders) in a rate law are determined by
   1. the coefficients in the balance equation.
   2. experiment.
   3. the physical states of the reactants and products.

   b. 2 only

3. After five half-life periods for a first-order reaction, what is the molarity of a reagent initially at 0.366 M?

   a. \(1.14 \times 10^{-2}\)

4. If the half-life of a first-order process is 3.00 minutes, the rate constant for the process is

   e. \(0.231/\text{min.}\)

5. Under which of the following conditions does the equilibrium constant \( K \) change for the reaction

   \[ \text{H}_2(\text{g}) + \text{I}_2(\text{g}) \leftrightarrow 2\text{HI}(\text{g}) \]

   d. changing the temperature

6. Hydrogen peroxide decays into water and oxygen in a first-order process.

   \[ \text{H}_2\text{O}_2(\text{aq}) \rightarrow \text{H}_2\text{O}(\cdot) + 1/2 \text{O}_2(\text{g}) \]

   where the rate expression is \(-\Delta[\text{H}_2\text{O}_2]/\Delta t = k[\text{H}_2\text{O}_2]\). If we begin with 0.100 M \( \text{H}_2\text{O}_2 \) and find that after 3200 seconds, the peroxide concentration falls to 0.0825 M, what is the rate constant, \( k \), at the temperature at which the experiment is performed?

   b. \(6.01 \times 10^{-5} \text{ s}^{-1}\)
7. In basic solution, \((\text{CH}_3)_3\text{CCl}\) reacts according to the equation

\[(\text{CH}_3)_3\text{CCl} + \text{OH}^- \rightarrow (\text{CH}_3)_3\text{COH} + \text{Cl}^-\]

The accepted mechanism for the reaction is

\[(\text{CH}_3)_3\text{CCl} \rightarrow (\text{CH}_3)_3\text{C}^+ + \text{Cl}^- \quad \text{(slow)}\]

\[(\text{CH}_3)_3\text{C}^+ + \text{OH}^- \rightarrow (\text{CH}_3)_3\text{COH} \quad \text{(fast)}\]

What is the rate law expression for the reaction?

d. \(\text{rate} = k[(\text{CH}_3)_3\text{CCl}]\)

8. The activation energy for \(2\text{N}_2\text{O}(g) \rightarrow 2\text{N}_2(g) + \text{O}_2(g)\) is 250. kJ. If \(k\) for this reaction is 0.380 \(\text{M}^{-1}\text{s}^{-1}\) at 1001 K, what will \(k\) be at room temperature, 298 K?

a. \(6.36 \times 10^{-32}\)

d. \(0.66\)

9. If \(K_c = 0.44\) for the reaction \(2\text{NOBr}(g) \leftrightarrow 2\text{NO}(g) + \text{Br}_2(g)\) at a particular temperature, what is \(K_c\) for the following reaction?

\[\text{NOBr}(g) \leftrightarrow \text{NO}(g) + \frac{1}{2}\text{Br}_2(g)\]

d. \(0.66\)

10. A chemist prepared a sealed tube with 0.85 atm of \(\text{PCl}_5\) at 500 K. The pressure increased as the following reaction occurred. When equilibrium was achieved, the pressure in the tube had increased to 1.25 atm. Calculate \(K_p\).

\[\text{PCl}_5(g) \leftrightarrow \text{PCl}_3(g) + \text{Cl}_2(g)\]

a. \(0.36\)

11. A 1.00 liter flask contained 0.24 mol \(\text{NO}_2\) at 700 K which decomposed according to the following equation. When equilibrium was achieved, 0.14 mol \(\text{NO}\) was present. Calculate \(K_c\).

\[2\text{NO}_2(g) \leftrightarrow 2\text{NO}(g) + \text{O}_2(g)\]

d. \(1.4 \times 10^{-1}\)
12. A mixture of 0.30 mol NO and 0.30 mole CO$_2$ is placed in a 2.00 L flask and allowed to reach equilibrium at a given temperature. Analysis of the equilibrium mixture indicated that 0.10 mol of CO was present. Calculate $K_c$ for the reaction.

\[
\text{NO(g) + CO}_2\text{(g) $\leftrightarrow$ NO}_2\text{(g) + CO(g)}
\]

c. 0.25

13. A flask contains the following system at equilibrium:

\[
\text{Mg(OH)}_2\text{(s) $\leftrightarrow$ Mg}^{2+}\text{(aq) + 2 OH}^{-}\text{(aq)}
\]

Which of the following reagents could be added to increase the solubility of Mg(OH)$_2$?

c. HCl

14. For the gas phase reaction, $3\text{H}_2 + \text{N}_2 \rightarrow 2\text{NH}_3$, how does the rate of disappearance of H$_2$ compare to the rate of production of NH$_3$?

c. The rate of disappearance of H$_2$ is 3/2 the rate of appearance of NH$_3$.

15. The reaction

\[
\text{CH}_3\text{CHO(g) $\rightarrow$ CH}_4\text{(g) + CO(g)}
\]

proceeds via the rate expression $\Delta[\text{CO}] / \Delta t = [\text{CH}_3\text{CHO}]^{3/2}$. What is the overall order of the reaction?

e. three-halves-order

16. The half-life for a first-order reaction at 550 ºC is 85 seconds. How long would it take for 23% of the reactant to decompose?

c. 32 seconds

17. The decomposition of phosphine, PH$_3$, follows first-order kinetics:

\[
4\text{PH}_3\text{(g) $\rightarrow$ P}_4\text{(g) + 6H}_2\text{(g)}
\]

The half-life for the reaction at 550 ºC is 81.3 seconds. How long does it take for the reaction to be 78.5% complete?

e. 180 seconds

18. What is the half-life of a first-order reaction which is 15% complete after 210 seconds?

e. 895 seconds
19. Calculate the activation energy, $E^0$, for

$$\text{N}_2\text{O}_5(g) \rightarrow 2\text{NO}_2(g) + \frac{1}{2} \text{O}_2(g)$$

given $k$ (at 25 °C) = 3.46 x $10^{-5}$/s and $k$ (at 50 °C) = 1.10 x $10^{-3}$/s. $R = 8.3145 \times 10^{-3}$ kJ/mol·K.

b. 111 kJ

20. In which case does the reaction go farthest to completion (to the products)?

a. $K = 10^4$

21. For the reaction below, what is the expression for $K_C$?

$$2\text{H}_2(g) + 2\text{FeO(s)} \leftrightarrow 2\text{Fe(s)} + 2\text{H}_2\text{O(g)}$$

d. $K_C = [\text{H}_2\text{O}]^2/[\text{H}_2]^2$

22. Consider the reaction $2\text{A(g)} \leftrightarrow \text{B(g)}$ where $K_C = 0.5$ at the temperature of the reaction. If 2.0 moles of A and 2.0 moles of B are introduced into a 1.00 liter flask, what change in concentrations (if any) would occur in time?

b. [A] increases and [B] decreases

e. [A] and [B] remain the same

23. Consider the reaction $\text{A(g)} \leftrightarrow 2\text{B(g)}$ where $K_C = 1.5$ at the temperature of the reaction. If 3.0 moles of A and 3.0 moles of B are introduced into a 1.00 liter flask, what change in concentrations (if any) would occur in time?

b. [A] increases and [B] decreases

24. Exactly 0.50 mole of sulfur trioxide, 0.10 mole of sulfur dioxide, 0.20 mole of nitrogen monoxide and 0.30 mole nitrogen dioxide are sealed in a 1.0-L flask at 1500 °C. The equilibrium constant $K_C$ is 0.24 for the following reaction.

$$\text{SO}_3(g) + \text{NO(g)} \leftrightarrow \text{SO}_2(g) + \text{NO}_2(g) \quad K_C = 0.24$$

When equilibrium is achieved, what changes in concentrations of $\text{SO}_3$ and NO will be observed?

a. $[\text{SO}_3]$ increases; $[\text{NO}]$ increases

25. For the equilibrium system

$$\text{H}_2\text{O(g)} + \text{CO(g)} \leftrightarrow \text{H}_2(g) + \text{CO}_2(g) \quad \Delta H = -42 \text{ kJ/mol}$$

$K$ equals 0.62 at 1260 K. If 0.10 mol each of $\text{H}_2\text{O}$, CO, $\text{H}_2$ and $\text{CO}_2$ (all at 1260 K) were placed in a 1.0 L thermally insulated vessel which was also at 1260 K, then when the system came to equilibrium

a. the temperature would decrease and the mass of CO would increase.