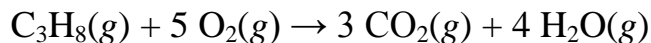
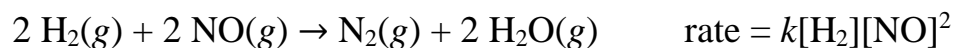


1. If $\text{O}_2(g)$ disappears at a rate of 0.250 M/s at a particular moment in the reaction below, what is the rate of appearance of $\text{H}_2\text{O}(g)$ at the same time?



- A. 0.0250 M/s C. 0.850 M/s
B. 0.120 M/s D. 0.200 M/s

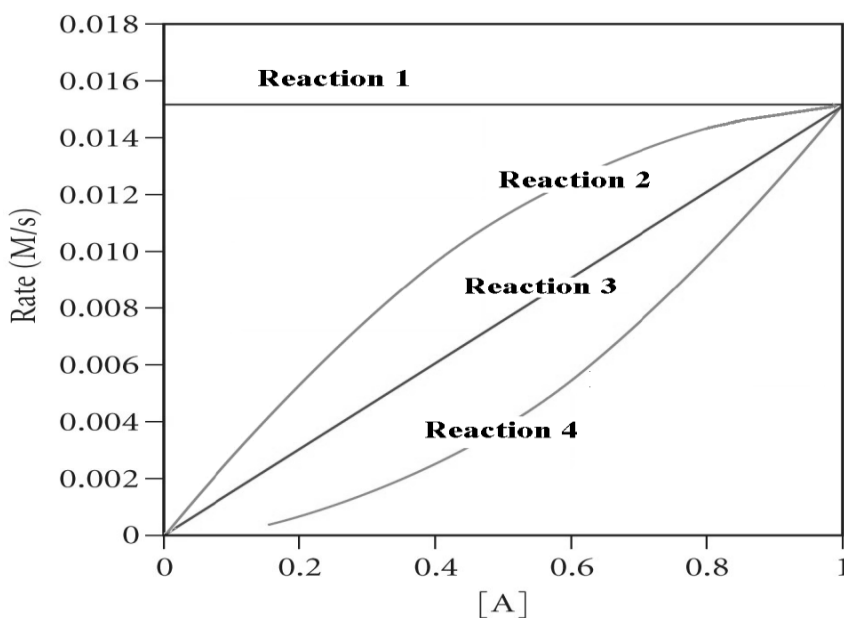
2. For the reaction



what is the effect on the **rate** if the concentration of H_2 is tripled and that of NO is doubled?

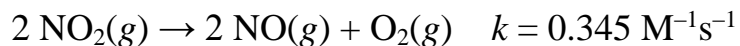
- A. The rate will increase by a factor of six.
B. The rate will increase by a factor of twelve.
C. The rate will increase by a factor of twenty-four.
D. The rate will decrease by a factor of six.

3. According to the plot, which of these reactions demonstrates first-order kinetics?



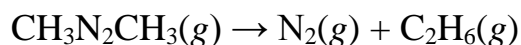
- A. Reaction 1 C. Reaction 3
B. Reaction 2 D. Reaction 4

-
4. Consider the following second-order reaction below. Starting with a concentration of 0.300 M, what is the NO_2 concentration after 3.00 minutes?



- A. 0.0153 M
B. 0.309 M
C. 0.00128 M
D. 0.174 M

-
5. The decomposition of azomethane at 300 °C follows first-order kinetics with a half-life of 272 s. How long must the reaction run for the final concentration of $\text{CH}_3\text{N}_2\text{CH}_3$ to be 20.0% of the initial concentration?

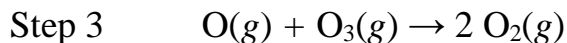
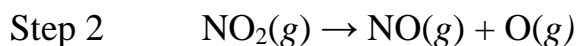
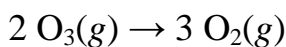


- A. 4.53 minutes
B. 10.5 minutes
C. 13.2 minutes
D. 22.7 minutes

-
6. A plot of $\ln k$ versus $(1/T)$ yields a line with a slope of $-2.63 \times 10^5 \text{ K}$. What information can we calculate from the slope?

- A. frequency factor, A
B. rate constant, k
C. activation energy, E_a
D. ideal gas constant, R
-

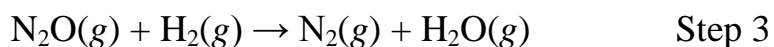
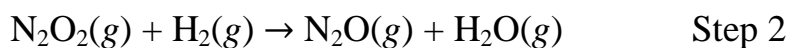
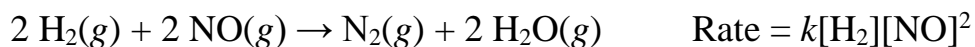
7. The following mechanism has been proposed for the reaction:



What are the functions of $\text{NO}(g)$ and $\text{NO}_2(g)$ in the reaction mechanism?

- A. NO and NO_2 are both intermediates.
- B. NO and NO_2 are both catalysts.
- C. NO is an intermediate and NO_2 is a catalyst.
- D. NO is a catalyst and NO_2 is an intermediate.

8. Given the balanced chemical equation and the experimental rate law, determine which is the slow (rate-determining) step in the proposed mechanism:

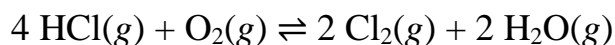


- A. Step 1
 - B. Step 2
 - C. Step 3
 - D. The slow step cannot be determined from the information given.
-

9. Which statement is **false** concerning a catalyst?

- A. Catalysts increase the reaction rate by increasing the temperature of a reaction.
- B. A catalyst is a reactant in an elementary step of a mechanism but is not consumed in the overall reaction.
- C. Catalysts increase the reaction rate by decreasing the activation energy of the rate-determining step.
- D. Catalysts can be homogenous or heterogeneous.

10. The reaction below has reached a state of dynamic equilibrium. Which one of the following statements about this reaction is **true**?



- A. The forward and reverse reactions have stopped.
- B. The concentration of $\text{O}_2(g)$ must be half the concentration of $\text{Cl}_2(g)$.
- C. The rates of the forward and reverse reactions are equal.
- D. The concentrations of the reactants and products are still changing with time.

11. Initially, 0.800 atm of $\text{CO}(g)$ and 2.40 atm of $\text{H}_2(g)$ are placed in a reaction vessel. Given the balanced chemical equation and K_p , what can be said about the equilibrium concentrations of reactants and products?

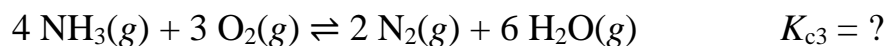


- A. The equilibrium lies far to the right and the partial pressures of the reactants will be significantly higher than the partial pressures of products.
 - B. The equilibrium lies far to the right and the partial pressures of the products will be significantly higher than the partial pressures of reactants.
 - C. The equilibrium lies far to the left and the partial pressures of the reactants will be significantly higher than the partial pressures of products.
 - D. The equilibrium lies far to the left and the partial pressures of the products will be significantly higher than the partial pressures of reactants.
-

12. Given



what will be the expression, K_{c3} , for



A.
$$K_{c3} = \frac{(K_{c1})^3}{(K_{c2})^2}$$

C.
$$K_{c3} = (K_{c1})^3 (K_{c2})^2$$

B.
$$K_{c3} = \frac{3 \times K_{c1}}{2 \times K_{c2}}$$

D.
$$K_{c3} = 6K_{c1}K_{c2}$$

13. Given



what is the value of K_p at 1973 K?

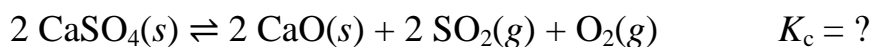
A. 2.73

C. 6.72×10^{-1}

B. 4.97×10^3

D. 5.95×10^2

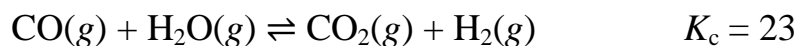
14. Calcium sulfate undergoes thermal decomposition according to the reaction



What is K_c for this reaction?

- A. $K_p = \frac{[\text{CaO}]^2[\text{SO}_2]^2[\text{O}_2]}{[\text{CaSO}_4]^2}$ C. $K_c = [\text{CaO}]^2[\text{SO}_2]^2[\text{O}_2]$
B. $K_c = \frac{[\text{SO}_2]^2[\text{O}_2]}{[\text{CaSO}_4]^2}$ D. $K_c = [\text{SO}_2]^2[\text{O}_2]$

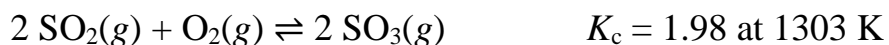
15. A reaction mixture initially contains 0.10 M CO and 0.10 M H₂O. What is the equilibrium concentration of CO₂ in the reaction below?



- A. 0.095 M C. 0.083 M
B. 0.018 M D. 0.10 M

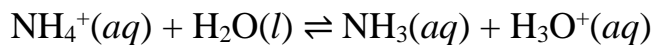
16. Which way will the reaction proceed given the following initial concentrations?

$$[\text{SO}_2] = 0.100 \text{ M}, [\text{O}_2] = 0.200 \text{ M}, [\text{SO}_3] = 0.200 \text{ M}$$



- A. to the left because $Q > K$ C. to the right because $Q > K$
B. to the left because $Q < K$ D. to the right because $Q < K$
-

-
20. Which pair identifies a Brønsted-Lowry **conjugate acid-base pair** and the function of each substance in the reaction below?



- A. H_2O , base; NH_3 , conjugate acid C. H_2O , acid; H_3O^+ , conjugate base
B. NH_4^+ , base; H_2O , conjugate acid D. NH_4^+ , acid; NH_3 , conjugate base

-
21. Which one of the following acids has the **highest** percent ionization at 0.450 M?

- A. HCN , $K_a = 4.9 \times 10^{-10}$ C. $\text{HC}_9\text{H}_7\text{O}_4$, $K_a = 3.3 \times 10^{-4}$
B. H_3BO_3 , $K_a = 5.4 \times 10^{-10}$ D. HNO_2 , $K_a = 4.6 \times 10^{-4}$

-
22. K_w for water is 5.48×10^{-14} at 50 °C. Which of the following statements about water at 50 °C is **false**?

- A. $[\text{H}^+] = 1.00 \times 10^{-7}$ M for pure water at 50 °C.
B. $[\text{OH}^-] = 2.34 \times 10^{-7}$ M for pure water at 50 °C.
C. $\text{p}K_w = 13.261$ for water at 50 °C.
D. $\text{pH} = 6.631$ for pure water at 50 °C.
-

23. A solution contains 0.050 M HClO_4 , 0.050 M HClO_2 , 0.050 M HClO , and 0.050 M HCl . Which acidic species contribute significantly to the $[\text{H}^+]$ and must be included in the pH calculation?

- A. HClO_4 and HClO_2 C. HClO_2 and HClO
B. HClO_4 and HCl D. HClO and HCl

24. What is the percent ionization of a 0.200 M solution of benzoic acid ($\text{HC}_7\text{H}_5\text{O}_2$, $K_a = 6.5 \times 10^{-5}$)?

- A. 20.0% C. 1.8%
B. 9.0% D. 0.036%

25. Which 0.500 M solution will have the **lowest** pH?

- A. piperidine, $\text{C}_5\text{H}_{10}\text{NH}$, $K_b = 1.33 \times 10^{-3}$
B. ammonia, NH_3 , $K_b = 1.76 \times 10^{-5}$
C. pyridine, $\text{C}_5\text{H}_5\text{N}$, $K_b = 1.70 \times 10^{-9}$
D. NaOH
-

Answer Key:

1. D
2. B
3. C
4. A
5. B
6. C
7. D
8. B
9. A
10. C
11. B
12. A
13. D
14. D
15. C
16. A
17. C
18. A
19. B
20. D
21. D
22. A
23. B
24. C
25. C