

Name Solution

(76) PART I. MULTIPLE CHOICE (Circle the ONE correct answer)

1. For the reaction, $A + B \rightarrow \text{Products}$, the rate law is $\text{Rate} = k \frac{[A]}{[B]^2}$. The units of the rate constant are:
- (A) M^3s^{-1} (B) M^2s^{-1} (C) $M^{-3}s^{-1}$ (D) $M^{-2}s^{-1}$
2. The rate of the chemical reaction involving two substances, A and B, is measured. It is found that if the initial concentration of A used is quadrupled, keeping the B concentration the same, the rate increases by a factor of 64 (relative to the first experiment). If the concentrations of both A and B are quadrupled, the rate increases by a factor of 16 (relative to the first experiment). The rate law for this reaction is: $\text{Rate} =$
- (A) $k[A]^2[B]$ (B) $k[A]^2[B]^{-1}$ (C) $k[A]^3[B]^{-1}$ (D) $k[A]^3[B]$
3. Consider a reaction, $A \rightarrow \text{Products}$, which is of order "n"; i.e. $\text{Rate} = k[A]^n$. For this reaction, the following initial rate data was obtained.
- When $[A]_0 = 0.20 \text{ M}$, the initial rate is 1.2 M/s
 When $[A]_0 = 0.80 \text{ M}$, the initial rate is 19.2 M/s
- The order of this reaction (i.e. "n") is:
- (A) +3 (B) +2 (C) +1 (D) -1
4. For the above reaction (question immediately above), the rate constant is approximately:
- (A) 6.0 s^{-1} (B) $150 \text{ M}^{-2}\text{s}^{-1}$ (C) $30 \text{ M}^{-1}\text{s}^{-1}$ (D) $0.24 \text{ M}^2\text{s}^{-1}$

For #5 - #7: Consider a reaction, $A \rightarrow \text{Products}$, which is of **first** order; i.e. $\text{Rate} = k[A]$. For this reaction, the rate constant is 0.015 s^{-1} at $100 \text{ }^\circ\text{C}$. The Activation Energy for this reaction is 75 kJ/mol .

5. For this reaction, a plot of _____ vs. time is a straight line with a _____ slope.
- (A) $\ln([A]_t)$, negative (B) $[A]_t$, negative
 (C) $1/[A]_t$, negative (D) $1/[A]_t$, positive

6. If the initial concentration of A is 1.30 M (at 100 °C), what will be the concentration of A 70 s after the start of the reaction?
 (A) 0.25 M (B) 0.36 M (C) 0.45 M (D) 0.58 M
7. What will be the value of the rate constant at 150 °C?
 (A) 0.26 s⁻¹ (B) 0.057 s⁻¹ (C) 8.6x10⁻⁴ s⁻¹ (D) 17.5 s⁻¹

For #8 - #9: Consider a reaction, $B \rightarrow \text{Products}$, which is 2nd. order; i.e. $\text{Rate} = k[B]^2$. The molecule, B, absorbs visible light at 500 nm. The Molar Absorptivity for this absorption is $\epsilon = 600 \text{ M}^{-1} \text{ cm}^{-1}$.

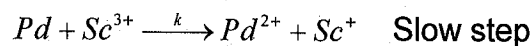
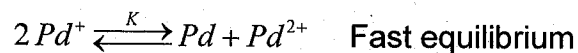
When a sample of B with initial concentration, $[B]_0 = 1.20 \times 10^{-3} \text{ M}$, is placed in a sample cell with cell pathlength = 2.0 cm, then the Percent Transmission 150 s after the start of the experiment is 30%.

8. The concentration of [B] 150 s after the start of the experiment is approximately:
 (A) 4.36x10⁻⁴ M (A) 1.82x10⁻⁴ M (A) 1.00x10⁻³ M (A) 8.71x10⁻⁴ M
9. The rate constant for this second order reaction is approximately:
 (A) 1.1 M⁻¹s⁻¹ (B) 2.1 M⁻¹s⁻¹ (C) 31.1 M⁻¹s⁻¹ (D) 9.7 M⁻¹s⁻¹
10. Which of the following statements is/are **TRUE**?
- X (1) The mechanism for a catalyzed reaction is the same as the mechanism of the same reaction without the catalyst.
- ✓ (2) The enthalpy change of the reaction is the same for the catalyzed reaction as for the uncatalyzed chemical reaction.
- ✓ (3) The intermediate in a reaction is generated in one of the earlier steps of a reaction and used up in later steps.
- X (4) The Rate Determining Step in a catalyzed reaction mechanism has a lower activation energy and, therefore, is slower than the Rate Determining Step for the uncatalyzed reaction.
- (A) 1 & 4 (B) 2 only (C) 2 & 3 (D) 2 & 3 & 4

11. Consider a reaction, $R \rightarrow P$ (i.e. Reactants \rightarrow Products). If the activation energy for the **forward** reaction is 40 kJ/mol and the activation energy for the **reverse** reaction is 85 kJ/mol, then the overall enthalpy (aka energy) change for this reaction is:

(A) +125 kJ/mol (B) -45 kJ/mol (C) -125 kJ/mol (D) +45 kJ/mol

12. For the reaction, $Sc^{3+}(aq) + 2 Pd^+(aq) \rightarrow Sc^+(aq) + 2 Pd^{2+}(aq)$, the reaction mechanism is:



The overall rate equation for this reaction is:

(A) $Rate = k' \frac{[Pd^{2+}][Sc^{3+}]}{[Pd^+]^2}$

(B) $Rate = k' \frac{[Pd^+][Sc^{3+}]}{[Pd^{2+}]}$

(C) $Rate = k' \frac{[Pd^+]^2 [Sc^{3+}]}{[Pd^{2+}]}$

(D) $Rate = k'[Pd][Sc^{3+}]$

13. When a substrate (S) binds **Strongly** to an enzyme (E) to form the complex, ES:

(A) K_m is small (B) V_m is small (C) V_m is large (D) K_m is large

14. In an enzyme catalyzed reaction, for approximately what ratio, $[S]/K_m$, does one find that $v_o = 0.4V_m$?

(A) $[S]/K_m = 1.50$ (B) $[S]/K_m = 1.20$ (C) $[S]/K_m = 0.83$ (D) $[S]/K_m = 0.67$

15. Consider the gas phase equilibrium, $A(g) \rightleftharpoons B(g) + 2C(g)$,

$K_c = 1.0 \times 10^{-4}$. 3.0 mol of A(g) is placed in a 4.0 L container and the mixture is allowed to come to equilibrium. Calculate the approximate concentration of C(g) at equilibrium.

NOTE: You can assume that very little A(g) reacts to form B(g) and C(g)

(A) $2.7 \times 10^{-2} M$ (B) $5.3 \times 10^{-2} M$ (C) $4.2 \times 10^{-2} M$ (D) $8.4 \times 10^{-2} M$

16. Consider the gas phase equilibrium $A(g) \rightleftharpoons 2 B(g)$. 3.0 moles of pure $A(g)$ are placed in a 2.0 L container, and the reaction is allowed to proceed to equilibrium. It is found that after equilibrium has been established, the concentration of $B(g)$ is 0.80 M. The value of the equilibrium constant, K_c , is approximately:

- (A) 0.15 (B) 0.43 (C) 0.58 (D) 0.73

For #17 - #19: For the gas phase reaction, $2 Br_2(g) + 4 NO(g) \rightleftharpoons 4 NOBr(g)$, $K_c = 50$. at 400 K.

17. For the above reaction, if the equilibrium concentrations (at 400 K) of $Br_2(g)$ and $NOBr(g)$ are each 2.5 M, then the equilibrium concentration of NO is approximately:

- (A) 1.7 M (B) 2.8 M (C) 0.59 M (D) 0.35

18. If a mixture is prepared with $[Br_2] = 0.7 M$, $[NO] = 0.7 M$ and $[NOBr] = 1.5 M$, the reaction quotient is approximately _____ and the reaction will proceed towards the

- (A) 43. , Right (B) 84 , Left (C) 43 , Left
(D) None of the above

19. The equilibrium constant for the related reaction $2 NOBr(g) \rightleftharpoons Br_2(g) + 2 NO(g)$, at 400 K is approximately:

- (A) 0.14 (B) 0.32 (C) 0.04 (D) 7.1

PART II. THERE ARE TWO (2) PROBLEMS ON FOLLOWING PAGES
You MUST show your work for credit.

- (12) 1. Consider the reaction, $A \rightarrow \text{Products}$, which is **third** order with respect to $[A]$; i.e. the rate is given by $\text{Rate} = k[A]^3$. It can be shown that the integrated rate equation for this reaction is given by:

The integrated rate equation for the reaction is: $\frac{1}{[A]^2} - \frac{1}{[A]_0^2} = 2kt$

$[A]_0$ and $[A]$ are the concentrations at $t = 0$ and t , respectively, and k is the rate constant.

- (8) (a) When the initial concentration of A is 0.90 M , the half-life for the reaction is $t_{1/2} = 60 \text{ s}$. Calculate the rate constant for the reaction (give units).

$[A]_0 = 0.90 \text{ M}$
 $[A] = \frac{1}{2}[A]_0 = 0.45 \text{ M}$
 when $t = t_{1/2} = 60 \text{ s}$

$$\begin{aligned}
 k &= \frac{1}{2t} \left[\frac{1}{[A]^2} - \frac{1}{[A]_0^2} \right] \\
 &= \frac{1}{2(60)} \left[\frac{1}{(0.45 \text{ M})^2} - \frac{1}{(0.90 \text{ M})^2} \right] \\
 &= 0.0309 \text{ M}^{-2} \text{ s}^{-1} \approx 0.031 \text{ M}^{-2} \text{ s}^{-1}
 \end{aligned}$$

- (4) (b) When the initial concentration of A is 0.90 M , calculate the concentration of A 100 s after the start of the reaction.

Note: If you don't like your answer for part (a), you can use $k = 0.035 \text{ M}^{-2} \text{ s}^{-1}$ (without loss of credit in this part).

$k = 0.0309 \text{ M}^{-2} \text{ s}^{-1}$
 $t = 100 \text{ s}$
 $[A]_0 = 0.9 \text{ M}$
 $[A] = ?$

$$\begin{aligned}
 \frac{1}{[A]^2} &= \frac{1}{[A]_0^2} + 2kt \\
 &= \frac{1}{(0.9 \text{ M})^2} + 2(0.0309 \text{ M}^{-2} \text{ s}^{-1})(100 \text{ s}) \\
 \frac{1}{[A]^2} &= 2.45 \text{ M}^{-2} \\
 [A]^2 &= \frac{1}{2.45} = 0.135 \text{ M}^2 \\
 [A] &= (0.135 \text{ M}^2)^{1/2} \\
 &= 0.37 \text{ M}
 \end{aligned}$$

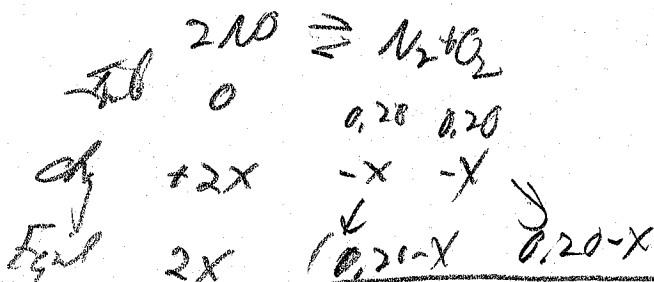
(12) 2. Consider the reaction: $2NO(g) \xrightleftharpoons{K_c} N_2(g) + O_2(g)$. The equilibrium constant is $K_c = 2$. at 1500 K.

2.0 mol of $N_2(g)$ and 2.0 mol of O_2 are placed in a 10 L container and heated to 1500 K, where equilibrium is established.

Calculate the equilibrium concentrations (in M) of NO, N_2 and O_2 in the equilibrium mixture.

$$[N_2]_0 = [O_2]_0 = \frac{2.0 \text{ mol}}{10 \text{ L}} = 0.20 \text{ M}$$

$$[NO]_0 = 0$$



$$K_c = 2.0 = \frac{[N_2][O_2]}{[NO]^2} = \frac{(0.20-x)(0.20-x)}{(2x)^2} = \frac{(0.20-x)^2}{(2x)^2}$$

Take Sq Root

$$\sqrt{K_c} = \sqrt{2} = 1.414 = \frac{0.20-x}{2x}$$

$$0.20-x = 2(1.414)x = 2.828x$$

$$3.828x = 0.20$$

$$x = \frac{0.20}{3.828} = 0.052 \text{ M}$$

$[N_2] = [O_2] = 0.20 - x = 0.20 - 0.052$
 $= 0.148 \text{ M} \approx 0.15 \text{ M}$

$[NO] = 2x = 2(0.052)$
 $= 0.104 \text{ M} \approx 0.10 \text{ M}$