3. CHEMICAL KINETICS

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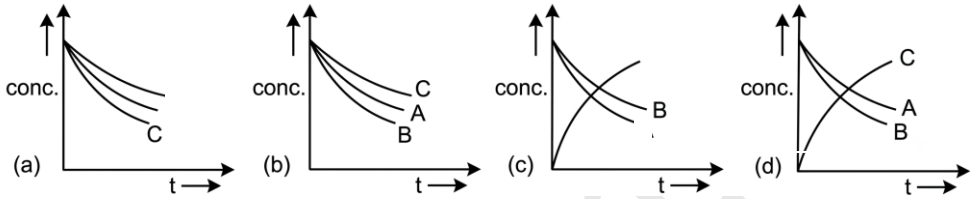
Introduction to the Rate of Reactions

1. The branch of chemistry that deals with the rate of reaction and factors affecting it is
   a. Thermodynamics c. Electrochemistry
   b. Chemical kinetics d. Chemical equilibrium
2. Rusting of iron can be treated as
   a. Fast reaction c. slow reaction
   b. Intermediate reaction d. very fast reaction
3. In the reaction: 3 A ⟶ 2 B; the rate of reaction $+\frac{d[B]}{dt}$ is equal to
   a. $-\frac{d[A]}{dt}$
   b. $-\frac{3}{2}\frac{d[A]}{dt}$
   c. $-\frac{2}{3}\frac{d[A]}{dt}$
   d. $-\frac{1}{3}\frac{d[A]}{dt}$
4. In the reaction: A ⟶ B + 2 C; which of the following is true?
   a. $-\frac{d[A]}{dt} = \frac{1}{3}\frac{d[B]}{dt}$
   b. $\frac{d[B]}{dt} = \frac{d[C]}{dt}$
   c. $\frac{d[C]}{dt} = 2 \times \frac{d[A]}{dt}$
   d. $\frac{d[C]}{dt} = -\frac{1}{2}\frac{d[A]}{dt}$
5. For the reaction $2N_2O_5 \rightarrow 4NO_2 + O_2$, the rate of reaction is:
   a) (1/2) $d[N_2O_5]/dt$
   b) (1/2) $d[N_2O_5]/dI$
   c) (1/4) $d[NO_2]/dt$
   d) (1/4) $d[NO_2]/dI$
6. For the reaction $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$, which of the following correctly relates the rates of disappearance of the reactants and appearance of the product?
   (A) $-d[N_2]/dt = -d[H_2]/dt = d[NH_3]/dt$
   (B) $-d[N_2]/dt = -(1/3)d[H_2]/dt = (1/2)d[NH_3]/dt$
   (C) $-d[N_2]/dt = -3\, d[H_2]/dt = 2\, d[NH_3]/dt$
   (D) $-3\, d[N_2]/dt = -d[H_2]/dt = 2\, d[NH_3]/dt$
7. The expression in which the rate of reaction in terms of all the species is made equivalent is
   a. Rate law equation c. Law of mass action
   b. Equivalent rate expression d. Arrhenius equation
8. For the reaction: $2\ SO_2 + O_2 \rightleftharpoons 2SO_3$. The rate of disappearance of O_2 is 2×10^4 mol $l^{-1}s^{-1}$. The rate of appearance of SO_3 is
   a. 2×10^{-4} mol l^{-1} s^{-1} c. 4×10^{-4} mol l^{-1} s^{-1}
   b. 1×10^{-4} mol l^{-1} s^{-1} d. 6×10^{-4} mol l^{-1} s^{-1}
9. Given the reaction A → B, the concentration of A decreases from 1.0 M to 0.7 M in 15 seconds. What is the average rate of the reaction?
   a. 0.01 M s^{-1} b. 0.02 M s^{-1}
   c. 0.03 M s^{-1} d. 0.05 M s^{-1}
10. The rate of reaction between two specific time intervals is called
   A) instantaneous rate c. average rate
   B) specific rate d. standard rate

11. The rate of reaction at a particular instant of time is
    a. Average rate of reaction c. Rate constant
    b. Instantaneous rate of reaction d. Specific rate of reaction
12. What is the primary difference between the average rate and the instantaneous rate of a chemical reaction?
    a. The average rate is time-independent, whereas the instantaneous rate is time-dependent.
    b. The average rate is determined over a finite time interval, whereas the instantaneous rate is determined at a specific moment in time.
    c. The average rate applies only to fast reactions, whereas the instantaneous rate applies only to slow reactions.
    d. There is no significant difference between the two.
13. A student plots the concentration of a reactant against time. The instantaneous rate at a particular moment is best found by:
    (A) Dividing the total concentration change by the total time
    (B) Measuring the slope of the chord between two widely separated points
    (C) Drawing a tangent to the curve at that specific time and measuring its slope
    (D) Calculating the average of all recorded rates
14. The unit of the rate of reaction is
    a. m/s b. Mol l^{-1} c. Mole l^{-1} s^{-1} d. mol s^{-1}
15. Which of the following graphs is a correct representation of the reaction
    A + 2 B → C?



16. In a reaction A → products, the concentration of A drops from 0.80 mol L^{-1} to 0.20 mol L^{-1} over 120 s. What is the average rate of this reaction?
    a. 5.0×10^{-3} mol L^{-1} s^{-1} b. 6.0×10^{-3} mol L^{-1} s^{-1} c. 5.0×10^{-2} mol L^{-1} s^{-1} d. 6.67×10^{-3} mol L^{-1} s^{-1}
17. Assuming the rate of a reaction is doubled for every 10 °C rise in temperature, how many times does the rate of temperature rise from 10 °C to 100 °C?
    A) 1024 times B) 100 times C) 512 times D) 90 times
18. The value of activation energy for a chemical reaction is primarily dependent on
    a. Temperature c. Collision frequency
    b. Concentration of the reactants d. Nature of reacting species
19. Which statement best describes an activated complex?
    a) It is a stable intermediate.
    b) It is a short-lived, high-energy species that forms before products.
    c) It is a low-energy state that slows the reaction.
    d) It is the final product of the reaction.

Collision Theory

20. 4.0g of powdered calcium carbonate, *Mr* = 100, are added to 100 cm^3 of 0.10mol dm^{-3} hydrochloric acid. The volume of carbon dioxide produced is recorded every 30 seconds.

time/s	30	60	90	120	150	180	210	240
total volume of carbon dioxide given off/cm^3	40	70	88	101	110	116	120	120

Which row of the table is correct?

	why rate of the reaction changes with time	why the reaction stops
A	fewer collisions between reacting molecules occur	the calcium carbonate is used up
B	fewer collisions between reacting molecules occur	the hydrochloric acid is used up
C	more collisions between reacting molecules occur	the calcium carbonate is used up
D	more collisions between reacting molecules occur	the hydrochloric acid is used up

21. According to collision theory, which of the following statements best explains why only some collisions lead to product formation?

a. All collisions are sufficiently energetic to cause a reaction.

b. Every collision results in the formation of products.

c. All collisions are effective collisions.

d. Only a fraction of collisions are effective because they possess sufficient energy to overcome the activation energy barrier.

22. According to collision theory, which of the following factors does not directly affect the rate of a chemical reaction?

a. Number of collisions per second
b. Activation energy
c. Orientation of colliding molecules
d. Molecular mass of the reactants

23. Two molecules collide with energy greater than E_a but the collision does not result in a reaction. The most likely explanation is:

(A) The temperature was too low

(B) The concentration of reactants was too low

(C) The molecules were not in the correct orientation

(D) The rate constant was too small

24. Which of the following statements is correct about the rate of reaction?

a. The rate of a reaction decreases with the passage of time as the concentration of reactants decreases.

b. The rate of a reaction is the same at any time during the reaction.

c. The rate of a reaction is independent of temperature change.

d. The rate of a reaction decreases with an increase in concentration of reactant(s).

25. The rate of a chemical reaction increases with

(a) increase in particle size of the reactants

(b) increase in temperature

(c) decrease in temperature

(d) decrease in concentration of reactants

26. The rate of a chemical reaction depends on

a. Concentration of the reactants
c. Temperature
b. Use of Catalyst
d. All of the above

27. The rate of a reaction depends on

(a) concentration of reacting species

(b) temperature

(c) surface area of the reactants

(d) all of the above

28. The rate of reaction always depends upon

a. initial concentration of reactants
b. temperature
c. pressure
d. volume

29. The rate of a reaction increases with

a. Increase in particle size of reactants
c. Increase in temperature
b. Decrease in temperature
d. Decrease in concentration of reactants

30. Under a given set of experimental conditions, with an increase in concentration of reactants, the rate of a chemical reaction

a. Remains unchanged
c. Increases
b. First decreases and then increases
d. Decreases

31. The rate of a chemical reaction is independent of

a. Molecularity
c. Nature of reactants
b. Concentration of reactants
d. Temperature of reaction

32. The factor that does not influence the rate of reaction is

a. nature of reactants
b. concentration
c. temperature
d. molecularity

33. In general, the rate of reaction can be increased by all the factors except

a. Increasing the temperature
c. Increasing the concentration of reactants
b. Increasing the activation energy
d. Using a catalyst

34. Iodine and propanone react according to the following equation.
$I_2(aq) + CH_3COCH_3(aq) \rightarrow CH_3COCH_2I(aq) + HI(aq)$
If the concentration of propanone is increased, keeping the total reaction volume constant, the initial rate of the reaction also increases.
What could be the reason for this?
A A greater proportion of collisions is successful at the higher concentration.
B The particles are further apart at the higher concentration.
C The particles have more energy at the higher concentration.
D There are more collisions per second between particles at the higher concentration.

35. Two vessels, X and Y, contain the same gaseous reaction mixture at the same temperature. Vessel X is at 1 atm, and vessel Y is at 4 atm. Which statement correctly explains the rate difference?
(A) Vessel Y has a higher rate because the activation energy decreases at higher pressure
(B) Vessel Y has a higher rate because higher pressure increases the fraction of molecules above E_a
(C) Vessel Y has a higher rate because the molecules are closer together, increasing collision frequency
(D) Both vessels react at the same rate because the temperature is identical

36. According to collision theory, why does the rate of a chemical reaction increase with an increase in temperature?
a. The number of collisions between reactant molecules increases.
b. The velocity of reactant molecules increases.
c. A greater fraction of reactant molecules possesses energy equal to or greater than the activation energy.
d. The activation energy of the reaction decreases.

37. Hydrochloric acid reacts with large pieces of calcium carbonate. The experiment is then repeated using powdered calcium carbonate under identical conditions. How does this change affect the activation energy and the collision frequency of the reaction?

Option	Activation Energy	Collision Frequency
A	Increases	Increases
B	Remains constant	Increases
C	Increases	Remains constant
D	Remains constant	Remains constant

38. Which of the following quantities can be calculated using the Arrhenius equation?
a. Order of reaction b. Activation energy c. Half-life d. Molecularity

39. Ionic reactions (e.g., $AgNO_3 + NaCl \rightarrow AgCl\downarrow + NaNO_3$) are almost instantaneous, while the reaction between H_2 and I_2 gases is much slower. This difference is best explained by:
(A) Ionic reactions occur at a lower activation energy because no covalent bonds need to be broken
(B) Gas-phase reactions have a lower frequency of collisions
(C) Ionic reactions always have a zero-order rate law
(D) H_2 and I_2 require a catalyst to react

40. A chemist observes that increasing the temperature from 25 °C to 35 °C roughly doubles the rate of a certain reaction. Which of the following is the PRIMARY reason given by collision theory?
(A) More molecules are present at higher temperatures
(B) The activation energy decreases by 50% at higher temperatures
(C) A significantly greater proportion of molecules possesses energy ≥ E_a at higher temperatures
(D) Pressure inside the vessel increases, increasing collision frequency

41. The Arrhenius equation K = Ae^(-Ea/RT) is a characteristic of:
a) The reaction medium b) The catalyst c) The solvent d) Reacting species

Catalysis

42. Which statement about catalysts is correct?
A They change the reaction pathway by decreasing the activation energy.
B They increase the rate of reaction by lowering the enthalpy change of the reaction.
C They increase the number of particles that have sufficient energy to react.
D Heterogeneous catalysts are in the same state as the reactant.

43. A catalyst accelerates the reaction because
    a. it brings reactants closer.
    b. It increases the activation energy.
    c. It lowers the activation energy.
    D. It forms a complex with the reaction.
44. A catalyst increases the rate of a chemical reaction by
    a. decreasing the free energy
    b. decreasing the heat of reaction
    c. decreasing the activation energy
    d. increasing the average speed of the reacting molecules.
45. A catalyst speeds up a chemical reaction by
    a. increasing the activation energy
    b. providing an alternative reaction path of lower activation energy
    c. shifting the equilibrium towards the side of the product (s).
    d. increasing the reaction enthalpy
46. Catalysts are widely used in industrial and chemical processes because they alter the rate of reaction. How does a catalyst increase the rate of a chemical reaction?
    a. By lowering the activation energy
    b. By increasing the concentration of reactants
    c. By changing the equilibrium constant
    d. By increasing the temperature
47. Which of the following increases the rate of a reaction without changing the equilibrium constant?
    a. Catalyst
    b. Pressure
    c. Temperature
    d. Concentration of reactants
48. A catalyst remains unchanged at the end of the reaction regarding
    a. Quantity
    b. Physical state
    c. Chemical composition
    d. Quantity and chemical compositions
49. Catalysis may be homogeneous or heterogeneous. Which of the following is an example of heterogeneous catalysis?
    a. Enzyme-catalyzed conversion of glucose
    b. Decomposition of hydrogen peroxide in the presence of manganese dioxide (MnO_2)
    c. Acid-catalyzed hydrolysis of an ester
    d. Ozone depletion catalyzed by chlorine radicals
50. Enzyme catalysis involves biological catalysts. Which of the following distinguishes enzymes from most other catalysts?
    a. They function only at high temperatures.
    b. They are highly specific and highly efficient.
    c. They increase the activation energy of reactions.
    d. They catalyze only gaseous reactions.
51. In enzyme-catalyzed reactions, why does the reaction rate reach a maximum at high substrate concentration?
    a. All enzyme molecules become saturated with substrate.
    b. The activation energy becomes zero.
    c. The temperature becomes constant.
    d. The enzyme is completely consumed.
52. Enzymes are
    a. carbohydrates b. fats c. protein d. fatty acid
53. Which of the following does not affect the rate of a reaction?
    a. Temperature
    b. Concentration of the reactants
    c. Enthalpy change of the reaction
    d. catalyst

The rate law

54. In which of the following cases is the reaction faster?
    a. $k = 10^2$ b. $k = 10^{-2}$ c. $k = 10^1$ d. $k = 10^0$
55. The rate constant of a reaction depends on
    a. Temperature
    b. Time of reaction
    c. Initial concentration of reactants
    d. Extent of reaction
56. The rate constant of a chemical reaction is changed if
    a. the reaction temperature is changed,
    b. the reaction particle size is changed,
    c. the initial concentration of the reactants is changed,
    d. the product concentration is increased
57. What does the rate constant (k) change if the concentration of the reactants is increased by 'x'
    a. ln k/x b. k/x c. x d. k

58. For the reaction:
m A + n B ⟶ products
The rate law is given as: rate = k $[A]^x$ $[B]^y$.
Then the overall order of reaction is
a. m b. n + m c. x + y d. n

59. The rate law for the reaction A + 2B → C is given by:
Rate=k[A][B]
If the concentration of B is doubled while the concentration of A remains constant, how will the reaction rate change?
a. It remains the same. b. It doubles.
c. It quadruples. d. It is reduced to half.

60. Benzene Diazonium Chloride (BDC) decomposes at 20 °C as: $C_6H_5N_2Cl \longrightarrow C_6H_5Cl + N_2$
The rate of evolution of nitrogen gas doubles when the initial concentration of the BDC is doubled. Therefore, the order of this reaction is
a. First c. Second
b. Independent of the initial concentration of the BDC d. Zero order

61. The order of the reaction is
a. sum of stoichiometric coefficients of all reactants
b. sum of stoichiometric coefficients of all reactants on which the rate depends
c. sum of the power of concentration of the reactants on which the rate depends
d. sum of the power of concentration of all the reactants

62. Order of reaction is
a. Theoretical number c. Not fractional
b. An experimental quantity d. Constant for a reaction

63. The unit of rate constant depends upon
a. Number of reactants c. concentration of terms
b. Order of reaction d. molecularly of reaction

64. The unit of rate constant (K) is mol lit^{-1} sec^{-1}; the reaction is
a. Zero order c. First order b. Pseudo first order d. Second order

65. If the rate constant of a reaction is 1.2 x 10^{-5} mol $L^{-1}min^{-1}$, what is the order of the reaction
a. 0 b. 1 c. 2 d. 3

66. . The unit of rate constant for a first-order reaction is:
a) mol L^{-1} s^{-1} b) L mol^{-1} s^{-1} c) s^{-1} d) L^2 mol^{-2} s^{-1}

67. For a rate law experiment, two gases (X) and (Y) are filled in a container. The rate law for the reaction was found to be, rate = k $[X]^2$ [Y]. What will be the rate of reaction when the pressure is doubled?
a. The rate will be doubled. C. The rate will become four times.
b. The rate will become six times. D. The rate will become eight times.

68. IF the rate of reaction is equal to the rate constant, what will be the order of the reaction?
a. 0 b. 1 c. 2 d. pseudo first

69. Rate constant has the same unit as the rate of the reaction for … order reaction.
a. Zero b. first c. second d. third

70. A zero-order reaction is one whose rate is independent of
a. Temperature of the reaction c. Concentration of the reactants
b. Concentration of the products d. The material of the vessel

71. If the rate of reaction is independent of the initial concentration of the reactant, what order of reaction is it?
A) Zero-order B) First-order reaction C) Pseudo-first order D) Second order reaction

72. The rate constant of a first-order reaction depends upon
a. Time c. concentration of reactant b. Temperature d. all of the above

73. Radioactive decay is
a. Zero order b. First order c. Second order d. Pseudo first order

74. Which of the following statements about the rate constant (k) in a rate law is correct**?**
a. It changes with the concentration of reactants.
b. It depends on the order of the reaction.
c. It remains constant at a given temperature.
d. It changes with the catalyst used but not with temperature.

75. Which order of reaction does the following reaction represent
RCOOR + H_2O **(H+)→** RCOOH + ROH
a. Zero order b. First order c. Pseudo first order d. Second order

76. What is the concentration of N_2O_5 in the following first-order reaction in which the rate is 2.4 x 10^{-5} mol L^{-1} s^{-1} and the rate constant is 3.0 x 10^{-5} s^{-1}?
$2\ N_2O_5 \rightarrow 4\ NO_2 + O_2$
a. 0.04 b. 1.2 c. 0.8 d. 14

77. For the first-order reaction A → products, the rate of reaction is 1.2×10^{-3} mol L−1s−1 when the concentration of A is 0.30 mol L^{-1}. What is the rate constant of the reaction?
a. 2.0×10^{-3} s^{-1} b. 4.0×10^{-3} s^{-1} c. 6.0×10^{-3} s^{-1} d. 8.0×10^{-3} s^{-1}

78. A reaction is first order with respect to A and second order with respect to B. How is the rate affected when the concentration of B is tripled?
a. Increases by 3 times d. increases by 6 times c. Increases by 9 times c. increases by 12 times

79. The specific rate constant of a first-order reaction depends on
a. Concentration of reactant c. Temperature
b. Concentration of product d. Time

80. The rate constant of a reaction is 2.1 x 10^{-2} mol^{-2} L^2 min^{-1}. The order of the reaction is
a. Zero b. first c. second d. third

81. A reaction has the rate law: rate = $k[A]^2[B]^0$. Which of the following is the correct interpretation?
(A) The rate depends on both [A] and [B]
(B) The rate depends only on [A]; changing [B] has no effect on the rate
(C) The reaction is first-order overall
(D) The stoichiometric coefficient of B must be zero

82. The hydrolysis of sucrose ($C_{12}H_{22}O_{11}$) in excess water follows the rate law: rate = $k[C_{12}H_{22}O_{11}]$. This is classified as a pseudo-first-order reaction. Which best explains why?
(A) The reaction truly involves only one reactant
(B) Water is present in large excess, so its concentration is effectively constant, making the rate appear first-order
(C) Water is a product of the reaction, not a reactant
(D) Sucrose acts as a catalyst in the reaction

83. Which of the following is true regarding molecularity?
a. Molecularity is theoretically determined
b. Molecularity is always equal to the order of the reaction
c. Molecularity can be a fractional number
d. Molecularity is the total number of reactant molecules in an elementary reaction

84. Molecularity is defined as the number of reacting species participating in an elementary step. Which of the following statements is correct?
a. Molecularity may be zero. b. Molecularity can be a fraction.
c. Molecularity is always a positive integer and is usually not greater than three.
d. Molecularity and reaction order are always equal.

85. For the reaction 2A + B → C + D, the experimentally determined rate law is $R=k[A]^2$. Which of the following statements is correct?
a. The reaction is second order overall.
b. The reaction is first order overall.
c. The reaction is second order in B.
d. The molecularity of the reaction is 2.

86. For a hypothetical reaction: $A_2 + B_2 \rightarrow 2AB$ mechanism is given as
Step 1: $A_2 \rightleftharpoons A + A$ (fast)
Step 2: $A + B_2 \rightarrow AB + B$ (slow)
Step 3: $A + B \rightleftharpoons AB$ (fast)
The molecularity of the slow step is
a. 0 b. 1 c. 1.5 d. 2

87. Molecularity of a reaction can be:
a) fraction b) zero c) negative d) whole number

88. A reaction involving two reactants cannot be
a. unimolecular reaction b. first-order reaction
c. pseudo first order reaction d. biomolecular reaction

Half Lives

89. In a zero-order reaction, the half-life period is:
a) inversely proportional to initial concentration
b) directly proportional to initial concentration
c) independent of initial concentration
d) proportional to the square of the initial concentration

90. The rate constant for a first-order reaction is 0.01 s^{-1}. What is its half-life period?
a. 100 seconds b. 0.00693 second c. 69.3 second d. 0.01 second

91. Half-life of a certain reaction is 50s, and it remains constant even if the initial concentration of the reactant is doubled. What is the order of reaction?
a. Zero b. first c. second d. pseudo-first

92. Half-life period of a first-order reaction is 1386 seconds. The specific rate constant of a reaction is:
a. $0.5 \times 10^{-2}\ s^{-1}$ b. $0.5 \times 10^{-3}\ s^{-1}$ c. $5.0 \times 10^{-5}\ s^{-1}$ d. $5.0 \times 10^{-4}\ s^{-1}$

93. What fraction of a reactant showing first order remains after 40 minutes if $t_{1/2}$ is 20 minutes?
a. ¼ b. ½ c. 1/8 d. 1/6

94. The half-life period of any first-order reaction is
a. Equal to half of the rate constant
b. Directly proportional to the initial concentration of the reactant
c. Independent of the initial concentration of the reactants.
d. Inversely proportional to the initial concentration of the reactants

95. The half-life of a first-order reaction depends on which of the following?
a. Initial concentration of the reactant b. Rate constant only
c. Temperature and pressure only d. Both a and b

96. The half-life period is independent of the initial concentration for the reaction in
a. zero order b. first order c. second order d. third order

97. The half-life of a reaction gets halved as the initial concentration of the reaction is doubled. What is the order of reaction?
a. 0 b. 1 c. 2 d. 3

98. The half-life of a first-order reaction is 20 minutes. How long will it take for the concentration of the reactant to decrease from 0.08 M to 0.01 M?
a) 20 min b) 60 min c) 40 min d) 50 min

Higher Level Questions

99. At what time does a zero-order reaction get 100% completed?
a) ∞ min b) 0 min c) c_o/K d) $c_o/2K$

100. Two gaseous reactants, A and B, are contained in a vessel. The experimental rate law for their reaction is: $Rate=k[A]^2[B]$
If the vessel is compressed at constant temperature so that the pressure of the system is doubled, what happens to the reaction rate?
a. It doubles b. It becomes four times
c. It becomes six times d. It becomes eight times

101. The average minimum energy that must be associated with the reactant molecules to be capable of forming products:
a. activation energy b. collision energy c. threshold energy d. transition energy

102. The rate law for the single-step reaction 2A + B → 2C is given by:
a) Rate = K[A][B] b) Rate = $K[A]^2[B]$ c) Rate = K[2A][B] d) Rate = $K[A]^2[B]^o$

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