Chemistry

Higher level

Paper 1A

Practice paper

Topic: Chemical Kinetics

Chemistry

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Paper 1A

Specimen paper

1 hour

Instructions to candidates

- Do not open this examination paper until instructed to do so.
- Answer all questions.
- For each question, choose the best answer.
- A clean copy of the chemistry data booklet is required.
- The maximum mark for this paper is [30 marks].

Section A

1. For the reaction 2A + B -> C, the rate expression is Rate = $k[A]^2[B]$. If the concentration of A is doubled and B is halved, the rate will:
   A. Remain the same
   B. Double
   C. Halve
   D. Quadruple

2. What are the correct units for the rate constant, k, if the overall order of the reaction is zero?
   A. s^{-1}
   B. mol dm^{-3} s^{-1}
   C. dm^3 mol^{-1} s^{-1}
   D. dm^6 mol^{-2} s^{-1}

3. Which feature of a reaction mechanism is known as the molecularity?
   A. The overall order of reaction
   B. The number of molecules participating in an elementary step
   C. The number of steps in the mechanism
   D. The total number of reactant molecules in the balanced stoichiometric equation

4. Which statements regarding the rate constant k are correct?
   I. Its value depends on the temperature.
   II. Its units depend on the overall order of the reaction.
   III. Its value depends on the initial concentration of reactants.
   A. I and II only
   B. I and III only
   C. II and III only
   D. I, II and III

5. In the Arrhenius equation $k = Ae^{-E_a/RT}$, what does A represent?
   A. Activation energy
   B. Temperature in Kelvin
   C. The pre-exponential (frequency) factor relating to successful collision geometry
   D. The ideal gas constant

6. Which plot yields a straight line for a zero-order reaction with a single reactant A?
   A. [A] against time
   B. ln[A] against time
   C. 1/[A] against time

D. Rate against [A]

7. If a reaction mechanism involves a slow first step followed by a fast second step, the rate expression will be determined by:
A. Only the reactants in the balanced overall equation.
B. The reactants involved in the fast step.
C. The reactants involved up to and including the slow step.
D. The concentration of the products.

8. Which statements are correct about a reaction mechanism with two steps?
I. There will be two transition states on the energy profile.
II. There will be one intermediate on the energy profile.
III. The overall activation energy is zero.
A. I and II only
B. II and III only
C. I and III only
D. I, II and III

9. The graph of Rate against Concentration for a second-order reaction is:
A. A horizontal line
B. A straight line through the origin
C. A curve passing through the origin with increasing gradient
D. A straight line with a negative gradient

10. How is the activation energy, E_a, calculated from a plot of ln k against 1/T?
A. E_a = gradient x R
B. E_a = -gradient / R
C. E_a = gradient / R
D. E_a = -gradient x R

11. A reaction has a rate expression Rate = k[X][Y]. Which statement is correct?
A. The reaction is zero order with respect to X.
B. The overall order is 1.
C. The mechanism must be a single elementary step involving X and Y colliding.
D. The order with respect to Y is 1.

12. What can be deduced from a first-order rate expression Rate = k[A]?
I. The half-life is constant.
II. A plot of Rate vs [A] is a straight line through the origin.
III. The reaction must be a single elementary step.

A. I and II only
B. II and III only
C. I and III only
D. I, II and III

13. Which statement is correct about the half-life of a first-order reaction?
A. It increases as concentration decreases.
B. It decreases as concentration decreases.
C. It is constant regardless of the reactant concentration.
D. It is directly proportional to the temperature.

14. What are the units of an overall second-order rate constant, k?
A. s^{-1}
B. mol dm^{-3} s^{-1}
C. dm^3 mol^{-1} s^{-1}
D. dm^6 mol^{-2} s^{-1}

15. What does the term 'rate-determining step' describe?
A. The elementary step with the lowest activation energy
B. The elementary step with the highest activation energy
C. The fastest step in a reaction mechanism
D. The only step in a simple single-step reaction

16. Which changes will affect the value of the rate constant, k?
I. Changing the temperature
II. Adding a catalyst
III. Changing the reactant concentration
A. I and II only
B. I and III only
C. II and III only
D. I, II and III

17. What is the effect of increasing temperature on the rate constant k?
A. It decreases exponentially.
B. It increases exponentially.
C. It remains constant.
D. It increases linearly.

18. If a plot of ln[A] against time yields a straight line with a negative slope, the reaction is:

A. Zero order
B. First order
C. Second order
D. Third order

19. An intermediate in a reaction mechanism is a species that:
A. Is a reactant in the overall equation.
B. Is produced in an early step and consumed in a later step.
C. Acts as a catalyst.
D. Appears in the overall balanced equation as a product.

20. For the Arrhenius equation: $\ln k = -E_a/RT + \ln A$. Which statements are correct?
I. The gradient of a ln k vs 1/T plot is negative.
II. The y-intercept is A.
III. T refers to the temperature in degrees Celsius.
A. I only
B. I and II only
C. I and III only
D. I, II and III

21. Which pair represents the y-intercept and the x-axis variable required to determine the pre-exponential factor A from the Arrhenius equation?
A. y-intercept = A, x-axis = 1/T
B. y-intercept = ln A, x-axis = T
C. y-intercept = ln A, x-axis = 1/T
D. y-intercept = k, x-axis = T

22. The reaction A + B -> C + D has mechanism: 1) A + A -> X (slow) 2) X + B -> C + D (fast). The rate expression is:
A. Rate = k[A][B]
B. Rate = $k[A]^2$
C. Rate = $k[A]^2[B]$
D. Rate = k[X][B]

23. A bimolecular elementary step involves the collision of:
A. One particle.
B. Two particles.
C. Three particles.
D. Zero particles.

24. Which are valid units for a first-order rate constant?
I. s^{-1}
II. min^{-1}
III. mol dm^{-3} s^{-1}
A. I only
B. I and II only
C. I and III only
D. I, II and III

25. Which statement is correct for a zero-order reaction?
A. The rate decreases as the reactant is consumed.
B. The concentration-time graph is a curve.
C. The rate is independent of the reactant concentration.
D. The half-life is constant.

26. Which technique would NOT be useful for deducing a reaction mechanism?
A. Measuring the initial rate at varying concentrations.
B. Identifying reaction intermediates spectroscopically.
C. Predicting stereochemical requirements for collisions.
D. Balancing the overall stoichiometric equation.

27. Why do termolecular collisions occur very rarely in reaction mechanisms?
A. Three particles colliding with perfect geometry simultaneously is highly improbable.
B. They require zero activation energy.
C. They only occur in endothermic reactions.
D. They are only present in zero-order reactions.

28. Which properties are characteristic of an intermediate in a reaction mechanism?
I. It is formed in one step and consumed in a subsequent step.
II. Its concentration can appear in the experimentally determined overall rate expression.
III. It corresponds to a local minimum on a potential energy profile.
A. I and II only
B. I and III only
C. II and III only
D. I, II and III

29. If the activation energy of a reaction is very large, the rate constant will respond to a temperature increase by:
A. Decreasing slightly.
B. Increasing slightly.

C. Increasing significantly.
D. Remaining unaffected.

Which experimental method is best suited to continuously monitor the rate of a reaction that produces a gas?
A. Titration
B. Colorimetry
C. Measuring change in volume using a gas syringe
D. Measuring change in pH

The rate constant k for a reaction has units of $dm^3\ mol^{-1}\ s^{-1}$. What is the overall order of the reaction?
A. Zero
B. First
C. Second
D. Third

32. Which methods can be used to determine the order of a reaction?
I. Method of initial rates
II. Shape of concentration-time graphs
III. Calculating reaction enthalpy
A. I and II only
B. I and III only
C. II and III only
D. I, II and III

According to the Arrhenius equation, a graph of ln k against 1/T yields a straight line. What is the gradient of this line?
A. E_a / R
B. $-E_a / R$
C. ln A
D. $-E_a$

In a zero-order reaction, what is the shape of a concentration-time graph?
A. A straight horizontal line
B. A straight line with a negative gradient
C. An exponential decay curve
D. An exponential growth curve

A mechanism involves a slow step followed by a fast step. What represents the slow step?

A. Intermediate
B. Transition state
C. Rate-determining step
D. Initiation step

Which factors can increase the rate of a chemical reaction?

I. Increasing the concentration of reactants
II. Increasing the temperature
III. Decreasing the particle size of a solid reactant

A. I and II only
B. I and III only
C. II and III only
D. I, II and III

Which statement best describes the function of a heterogeneous catalyst?

A. It is in the same phase as the reactants.
B. It increases the kinetic energy of the particles.
C. It provides a surface for adsorption, lowering the activation energy.
D. It shifts the equilibrium position to the right.

Which parameters can be determined from the Arrhenius equation?

I. Activation energy (E_a)
II. Frequency factor (A)
III. Enthalpy change (Δ H)

A. I and II only
B. I and III only
C. II and III only
D. I, II and III