



Attempt all questions before checking the answer key. Use $\ln 2 = 0.693$, $\ln 10 = 2.303$ and $R = 8.314 \text{ J mol}^{-1} \text{ K}^{-1}$. Give units of every rate constant.

A. Very short answers - 1 mark each

1. Define average rate of a reaction.
2. What is the order of a reaction?
3. Can molecularity be zero or fractional? Explain briefly.
4. State the units of the rate constant for a first-order reaction.
5. What is activation energy?
6. Does a catalyst change the equilibrium constant at a fixed temperature?

B. Short answers / practice - 2 marks each

7. For $2\text{N}_2\text{O}_5 \rightarrow 4\text{NO}_2 + \text{O}_2$, relate the rates of disappearance/appearance of the three species.
8. For rate $= k[\text{A}]^2[\text{B}]$, find overall order and the change in rate when $[\text{A}]$ doubles with $[\text{B}]$ fixed.
9. Distinguish order from molecularity using two points.
10. A first-order reaction has $k = 2.31 \times 10^{-3} \text{ s}^{-1}$. Find its half-life.
11. Explain why temperature often has a strong effect on reaction rate.
12. State the slope and intercept of a plot of $\ln k$ against $1/T$.
13. A first-order reaction has half-life 10 min. Find k .
14. Find fraction remaining after three first-order half-lives.
15. Can reaction order be fractional?
16. For rate $= k[\text{A}]^2$, how does rate change if $[\text{A}]$ triples?
17. A zero-order process has $k = 0.02 \text{ M/s}$ and $[\text{A}]_0 = 0.20 \text{ M}$. Find depletion time.
18. Explain why a catalyst lowers activation energy without changing ΔG° .

C. Short answers - 3 marks each

19. For a reaction, doubling $[\text{A}]$ at fixed $[\text{B}]$ doubles rate; doubling $[\text{B}]$ at fixed $[\text{A}]$ quadruples rate. Find the rate law and units of k if concentration is mol/L and time is seconds.
20. A first-order reaction is 75% complete in 40 min. Find k and half-life.

21. A zero-order reaction has $[\text{A}]_0 = 0.20 \text{ M}$ and $k = 0.005 \text{ M/min}$. Find half-life and concentration after 30 min.

22. At fixed temperature, initial $[\text{A}]$ values 0.10, 0.20, 0.40 M give rates 0.002, 0.008, 0.032 M/s. Find order and k .

23. For a first-order process, $[\text{A}]$ falls from 0.80 to 0.20 M in 100 s. Find the additional time to reach 0.05 M.

24. Explain a pseudo-first-order reaction using hydrolysis of an ester in excess water; distinguish the full rate law from the observed simplified form.

D. Long answers - 5 marks each

25. Derive the integrated first-order rate equation and its half-life expression. Explain how concentration-time data can test first-order behaviour.

26. Derive the integrated zero-order rate equation and half-life expression. Sketch concentration versus time and compare its half-life dependence with first order.

27. A reaction's rate constant doubles when temperature rises from 300 K to 310 K. Use the Arrhenius equation to calculate activation energy and state assumptions.

28. Explain collision theory in terms of collision frequency, sufficient energy and orientation. Use a reaction-energy diagram to show how a catalyst changes the pathway.

29. A first-order reaction is 20% complete in 10 min. Find k , half-life and time for 90% completion; use $\ln 1.25 = 0.2231$. Explain why equal fractions react in equal time intervals.

30. For $2\text{A} \rightarrow \text{products}$, define disappearance rate of A and reaction rate carefully. If $-\text{d}[\text{A}]/\text{dt} = k[\text{A}]$, derive $[\text{A}](t)$ and explain how a rate constant defined through reaction rate would differ by a stoichiometric factor.

ANSWER KEY - Numerical / short answers

3) No; molecularity is a positive integer for an elementary step. 6) No. 8) Order 3; rate becomes four times. 10) 300 s. 13) 0.0693 min^{-1} . 14) $1/8$. 15) Yes. 16) Nine times. 17) 10 s. 19) Rate $= k[\text{A}][\text{B}]^2$; k units $\text{L}^2 \text{ mol}^{-2} \text{ s}^{-1}$. 20) 0.03465 min^{-1} ; 20 min. 21) 20 min; 0.050 M. 22) Order 2; $k = 0.20 \text{ L mol}^{-1} \text{ s}^{-1}$. 23) 100 s. 27) $\approx 53.58 \text{ kJ/mol}$. 29) $k = 0.02231 \text{ min}^{-1}$; half-life $\approx 31.06 \text{ min}$; 90% time $\approx 103.23 \text{ min}$. 30) $[\text{A}] = [\text{A}]_0 e^{(-kt)}$; if reaction rate $= k_r[\text{A}]$, $k_r = k/2$.