Introductory Rate Laws and Rate-Data Reasoning

Student Worksheet | `g10_u03_w12`

I can: compare initial-rate data to build and test a limited rate-law model, while distinguishing model evidence from a mechanism claim.
Classroom model: all trials below use the same stated reaction system, temperature, volume, measurement method, and initial-rate interval. A fitted expression such as rate $= k[\mathrm{A}]^m[\mathrm{B}]^n$ summarizes a data pattern under those conditions. Exponents are determined from data, not from equation coefficients, and they do not by themselves prove molecularity or a detailed mechanism. All prompts are paper/data-card analyses; no reaction, heating, or chemical handling is requested.

Trial	$[\mathrm{A}]_0$ (M)	$[\mathrm{B}]_0$ (M)	Initial rate ($\mathrm{M\,s^{-1}}$)
1	0.100	0.100	0.00300
2	0.200	0.100	0.00600
3	0.100	0.200	0.0120
4	0.200	0.200	0.0240

Supplemental graph card: At $[\mathrm{B}]_0 = 0.100$ M, initial rates measured for $[\mathrm{A}]_0 = 0.100$, 0.200, and 0.300 M are 0.00300, 0.00600, and 0.00900 $\mathrm{M\,s^{-1}}$, respectively. This is a stated data set for plotting, not a mechanism diagram.

1. Define an initial rate. Why is it useful to compare trials near the same initial condition?

2. What variables must be held constant when comparing the effect of one reactant concentration on an initial rate? Name at least three.

3. Compare trials 1 and 2. What factor changes for $[\mathrm{A}]_0$, what factor changes for rate, and what is held fixed?

4. Under this data model, what exponent for [A] is consistent with trials 1 and 2? Show the proportional reasoning.

5. Compare trials 1 and 3. What exponent for [B] is consistent with the factor pattern?

6. Use trials 1 and 4 to test the combined exponents from items 4–5. What rate factor is predicted and observed?

7. Write the rate-law model consistent with all four trials. State its scope in a phrase.

8. Use trial 3 to calculate k for your model. Keep units.

9. Derive the units of k from your rate-law model when rate is in $\mathrm{M\,s^{-1}}$.

10. Use your k to predict the initial rate for $[\mathrm{A}]_0 = 0.150$ M and $[\mathrm{B}]_0 = 0.200$ M.

11. Use your model to predict the rate for $[\mathrm{A}]_0 = 0.100$ M and $[\mathrm{B}]_0 = 0.300$ M. What is the rate factor relative to trial 1?

12. For the supplemental graph card, specify the horizontal and vertical axes, including units. What direct visual pattern should the three points show?

13. Why would a straight initial-rate versus [A] graph at fixed [B] be consistent with first power in [A] for this model? Why is the graph not a proof of an elementary step?

14. If [A] stays fixed and [B] triples, what factor does your model predict for rate?

15. A repeat of trial 3 gives 0.0118 $\mathrm{M\,s^{-1}}$ rather than 0.0120 $\mathrm{M\,s^{-1}}$. Give two cautious reasons a repeat can differ slightly without immediately rejecting the model.

16. Why should a fitted rate law be treated as a model tied to stated concentrations, temperature, and measurement conditions rather than a universal fact?

17. Correct this claim: "The exponent 2 for [B] proves that two B particles collide in the only reaction step."

18. A catalyst is added to an otherwise similar system. Why should you collect new rate data rather than assume the same k or fitted model applies unchanged? What thermodynamic claim remains inappropriate from rate data alone?

19. A temperature increase changes measured initial rates. What kinetic parameter in a rate-law model can change with temperature? Why does that observation not by itself state ΔH, ΔG, or equilibrium position?

20. Write a cautious claim-evidence-reasoning statement for the table. Include the two factor comparisons, your fitted model, one prediction it makes, and one mechanism limitation.