Collision Theory and Rate Measurements

Student Worksheet | `g10_u03_w09`

I can: use collision theory to explain cautious rate trends and calculate an average reaction rate from supplied concentration-time data.
Classroom model: a productive collision between reacting particles requires an encounter with sufficient energy and a suitable orientation where orientation matters. A rate is a measured change per time under stated conditions. Use average disappearance rate $= -\Delta[\mathrm{R}]/\Delta t$ and average appearance rate $= \Delta[\mathrm{P}]/\Delta t$. A rate trend is evidence about conditions, not proof of a full mechanism. All prompts are supplied paper/data-card analyses; no reaction, heating, or chemical handling is requested.

1. Define chemical kinetics and distinguish reaction rate from ΔH or ΔG.

2. State the three collision-model features that can make an encounter productive. Why is merely saying "the particles collided" incomplete?

3. Two collisions have the same energy but different orientations. Explain why one can be productive while the other is not in this classroom model.

4. A relative-energy card shows a threshold between reactants and an activated arrangement. What does the threshold represent? Why does a lower threshold not by itself prove a reaction is thermodynamically favorable?

5. Under otherwise matched conditions, explain how a higher reactant concentration can increase the observed rate in a collision model. State one variable that must be controlled for a fair comparison.

6. Under otherwise matched conditions, explain why a higher temperature can increase the observed rate. Do not say that every collision reacts.

7. A solid reactant is represented as smaller pieces rather than one large piece, with the same total amount. Explain a collision-model reason the measured rate can change.

8. Why must a rate claim name the measured quantity, time interval, temperature, and system boundary or conditions?

9. Write the average disappearance-rate expression for reactant R. Why does the leading negative sign produce a positive reported rate when [R] decreases?

10. A reactant card records [R] changing from 0.800 M to 0.620 M in 45.0 s. Calculate the average disappearance rate.

11. Write the average appearance-rate expression for product P. How does its sign convention differ from item 9?

12. A product card records [P] changing from 0.000 M to 0.150 M in 30.0 s. Calculate the average appearance rate.

13. In two consecutive 20.0 s intervals, [R] changes from 0.500 to 0.420 M, then from 0.420 to 0.360 M. Calculate the two average disappearance rates. What limited trend does the data support?

14. Matched cards give: Trial A, $[A]_0 = 0.200$ M, rate $= 0.0040\ \mathrm{M\,s^{-1}}$; Trial B, $[A]_0 = 0.400$ M, rate $= 0.0080\ \mathrm{M\,s^{-1}}$. State the proportional pattern and one conclusion you should *not* make from only these two cards.

15. A temperature card reports a rate of $0.0050\ \mathrm{M\,s^{-1}}$ at 293 K and $0.010\ \mathrm{M\,s^{-1}}$ at 313 K, with other listed conditions matched. Calculate the rate factor and give a collision-model interpretation.

16. A learner says, "Higher temperature makes the reaction more spontaneous." Correct the claim by separating a kinetic rate observation from a thermodynamic direction claim.

17. A catalyst data card shows a faster rate under otherwise matched conditions. Explain the cautious energy-pathway claim you can make and one claim you cannot make about the net ΔH or equilibrium state.

18. A reaction has a negative ΔG under stated conditions but an extremely small measured rate. Explain why those statements can coexist.

19. A report says, "Doubling concentration doubled rate, so the reaction must have a one-step mechanism with one reactant particle." Identify the overclaim and name one additional kind of evidence needed.

20. Design a data-only fair-test plan for one factor (concentration, temperature, surface area, or catalyst). Name the measured rate quantity, one independent variable, at least two controls, and one limitation of the collision model.