COLLISION THEORY

CHEMISTRY / REACTION RATES / TEACHER ANSWER KEY

Suggested answers. Equivalent scientifically correct wording should be accepted. Calculations refer to the illustrative figures in the student worksheet.

A–B | Collision theory and orientation

1. Reactant particles must collide for a reaction to be possible; reaction occurs only when collisions are successful.

2. The particles must have kinetic energy at least equal to the activation energy and a suitable orientation for the necessary bonds to break/form.

3. Some collisions have insufficient energy; others have unsuitable orientation, so reactants separate unchanged.

4. successful; second (or unit time).

5. A must approach the B end of BC so it can form an A–B bond while the B–C bond is rearranged/broken.

6. Collision 1. A approaches the B end, allowing formation of AB; Collision 2 approaches C first.

7. No. A correctly oriented collision must also have enough kinetic energy to overcome the activation-energy barrier.

8. Only a proportion of collisions have both the required energy and suitable orientation.

C | Activation energy

9. The minimum collision energy needed to overcome the energy barrier and form products via the particular reaction pathway.

10. 100 − 40 = 60 kJ/mol.

11. 70 − 40 = 30 kJ/mol.

12. A catalyst provides an alternative pathway with lower activation energy, so a greater fraction of collisions has sufficient energy and can succeed.

13. No. Both pathways begin at 40 kJ/mol and end at 20 kJ/mol. Catalysis changes the barrier, not the overall reactant/product energy difference.

D | Successful collisions

14. (12 ÷ 100) × 100 = 12%.

15. Successful collisions double from 12/s to 24/s because more reactant particles per unit volume produce more collisions per second (100 to 200 here). The success fraction remains 12%.

16. Higher temperature produces somewhat more collisions, but especially a larger fraction energetic enough to exceed activation energy: 36/120 = 30%, versus 12% at baseline.

17. The catalyst reduces activation energy; more of the 100 collisions/s have sufficient energy to lead to reaction. The success count increases from 12 to 30/s.

18. Higher temperature: 36 successful collisions per second, the greatest in the table.

E | Experimental observations

19. Equal-mass powder has greater exposed surface area; more acid particles can collide with the solid per second, increasing successful collisions per second.

20. At higher temperature, particles have more kinetic energy and move faster. More collisions occur, and a larger fraction have enough energy to overcome activation energy.

21. Reactant concentration decreases, reducing collision frequency and therefore the number of successful collisions each second.

22. The catalyst offers an alternative reaction pathway with lower activation energy, increasing the fraction of suitable collisions that succeed; it is not used up overall.

F–G | Data, investigation and evaluation

23. A: (42 − 0) ÷ 20 = 2.1 cm^3/s. B: (24 − 0) ÷ 20 = 1.2 cm^3/s.

24. Trial A. It forms 42 cm^3 in the first 20 s rather than 24 cm^3; higher temperature increases kinetic energy and the fraction of collisions energetic enough to react.

25. Both start with the same amounts of reactants, so the limiting reactant permits the same final quantity of gas; higher temperature changes how quickly that amount is produced.

26. Independent: temperature. Dependent: gas volume per unit time / volume collected in a fixed time / time to collect a fixed volume. Controls: magnesium mass and surface area, acid concentration, acid volume, apparatus (any two sensible controls).

27. For example, use an airtight flask and gas syringe, start timing immediately on mixing, record gas volume every 10 s, repeat each temperature at least three times, calculate rates and compare repeat values; check for gas leaks/delayed starting as sources of error.

28. Incorrect. Catalysts generally lower activation energy by providing an alternative pathway; they do not inherently increase particle kinetic energy. Not every collision succeeds: orientation can still be unsuitable and energy may remain insufficient.