Beneath the Bubbles

Use particle collisions to explain reaction rates

CHE.3.d "Construct an explanation, using particle diagrams and collision theory, for how particle size, concentration, and temperature affect the rate of a chemical reaction."

NAME _____ DATE _____

1 READ AND MARK

Read it twice

YOUR JOB Underline each change to particle size, concentration, or temperature. Circle the collision change it causes so you can connect each condition to reaction rate.

Why Chalk Bubbles

1. A chalk chip bubbles when it reacts with vinegar. The chalk contains calcium carbonate, and the bubbles are carbon dioxide. Acid particles in the vinegar must strike exposed chalk particles with enough energy and a useful orientation for a reaction to occur. Imagine a particle diagram: touching squares form one chalk chip, while dots represent acid particles around it. Crush the chip without changing its mass. More squares become exposed along the edges of smaller pieces, so more successful collisions can happen each second.

2. Suppose you keep the chalk pieces, vinegar volume, and temperature the same but use vinegar with a higher acid concentration. There are now more acid particles in the same volume of liquid. In a particle diagram, show more dots around identical chalk pieces, not larger squares or faster arrows. More acid particles can reach the exposed chalk surfaces each second, increasing the number of possible successful collisions. The chalk itself has not become more reactive; the frequency of surface encounters has changed.

3. Next, keep the chip size and acid concentration steady but warm the vinegar. Its particles move faster, so a diagram could show longer motion arrows beside the same number of acid dots. Faster particles collide with the chalk surface more often. Also, a larger fraction of collisions have enough energy to react. Do not confuse temperature with concentration: warming the same vinegar does not add acid particles. In each comparison, change just one condition to explain which collision pattern causes the rate to change.

2 ANSWER WITH EVIDENCE

Use the passage

1. A student breaks a solid reactant into smaller pieces before adding acid. Why should the reaction speed up?

2. Two cups hold equal volumes of acid and identical solid pieces. One cup has more acid particles per volume. Describe the difference you would draw and explain its effect on rate.

3. One of two otherwise identical mixtures is warmer. What two changes in its collisions explain the faster reaction?

4. Two particle sketches show identical solid pieces and equal numbers of acid dots, but one has longer motion arrows. Which condition changed, and why does the rate change?

3 YOUR TURN

Your own words

Marble contains calcium carbonate and reacts with acid. Starting with one marble chip in cool, dilute acid, draw three panels showing what changes if you crush the chip, use more concentrated acid, or warm the acid. Change only one condition per panel, label your particles and motion arrows, and write one sentence below each panel explaining its rate.

Beneath the Bubbles

PART 1 · READ AND MARK

Underline each change to particle size, concentration, or temperature. Circle the collision change it causes so you can connect each condition to reaction rate. Accept any marking that follows this job and points at the right text.

PART 2 · ANSWERS

#	QUESTION	ANSWER
1	A student breaks a solid reactant into smaller pieces before adding acid. Why should the reaction speed up?	**Smaller pieces expose more of the solid's surface, allowing more successful collisions with acid particles each second.**
2	Two cups hold equal volumes of acid and identical solid pieces. One cup has more acid particles per volume. Describe the difference you would draw and explain its effect on rate.	**Draw more acid dots around the same solid pieces. More acid particles can reach the exposed surface each second, increasing the rate.**
3	One of two otherwise identical mixtures is warmer. What two changes in its collisions explain the faster reaction?	**Particles collide with the solid more often, and a larger fraction of collisions have enough energy to react.**
4	Two particle sketches show identical solid pieces and equal numbers of acid dots, but one has longer motion arrows. Which condition changed, and why does the rate change?	**Temperature increased. Faster particles collide more often, and more collisions have enough energy to react.**

PART 3 · YOUR TURN (SAMPLE ANSWER)

Panel 1: Several smaller clusters of marble squares have more exposed edges than the original chip, so acid dots can collide with the surface more often. Panel 2: The original marble chip has more acid dots around it in the same volume, so surface collisions occur more often. Panel 3: The original chip and number of acid dots are unchanged, but longer motion arrows show faster particles, so collisions occur more often and more have enough energy to react.

Accept diagrams with different symbols if the solid, acid particles, and motion are labeled. Each panel should change only its assigned condition and connect that change to successful collisions.