Reaction rates: surface area and concentration

Teacher / technician

YEAR 10 / LESSON 38 / CHEMISTRY + SCIENCE (DOUBLE AWARD)

Staff preparation and answer guidance. Keep separate from student sheets. Live low-volume marble/acid investigation. Two repeats per pair; class shares A/B/C comparisons. No whoosh bottle, flammable solvent or heating.

Coverage and delivery

3.9–3.11: investigating surface area and concentration; rate measurements and collision explanations. Temperature is controlled here, not varied.

Allow about 60 minutes. Follow the student sequence and use the answers to check reasoning.

Requisition • class of 30, working in 15 pairs

Item	Per pair / setup	Class total
Booklet / writing tools	1 per learner	30 sets
Gas syringe/flask/stand/timer	1 tested set per pair	15 sets
Eye protection / cylinder / balance access	1 protector each; equipment per pair	30 protectors; 15 cylinders
Sorted marble chips	0.20 g × 2 per pair	8 g incl. spare
HCl working solutions	10.0 cm^3 per run	1.0 M: 250 cm^3; 0.5 M: 125 cm^3

Immediate safety

Wear eye protection; avoid acid splashes and report them immediately. Keep the syringe plunger free and tubing unobstructed. Stop if apparatus sticks or pressurises; call the teacher. Handle glassware carefully. No flames or heating.

Preparation and delivery

Read alongside the student method

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1. For 30 learners use 15 pairs split into five pairs each for A, B and C. Each pair performs two repeats of its assigned condition, yielding ten runs per condition. Supply 15 checked syringe/flask assemblies and eye protection; 30 runs require 6.0 g marble total (supply 8 g sorted chips).

2. Each run uses 10.0 cm^3 acid. Class totals are 200 cm^3 of 1.0 mol dm^{-3} HCl and 100 cm^3 of 0.5 mol dm^{-3} HCl; prepare 250 and 125 cm^3 respectively for dispensing losses. Prepare labelled working solutions using school stock procedures.

3. Use 0.20 g marble to keep expected gas below 50 cm^3, leaving margin in a 100 cm^3 syringe. Both acid amounts exceed the 4 mmol HCl needed for 0.20 g pure $CaCO_3$. Do not substitute larger masses, powder, smaller syringes or stronger acid.

4. Trial chip size and timing before class. Staff check free syringe travel, secure supports, gas path and leaks. If equipment sticks, pupils stop and call staff; do not operate a blocked pressure system. No flame or whoosh bottle belongs to this investigation.

5. Allow 10 minutes setup, 15 collection/repeats, 15 shared graphs and 10 evaluation/cleanup. Pooling pairs introduces equipment differences; keep raw repeats visible and discuss this limitation. Handle final dilute mixtures under the school disposal plan.

Close of lesson

• After reaction stops, staff direct collection/disposal of dilute mixtures and leftover chips. Rinse equipment as instructed; return dry apparatus and wash hands.

Check before teaching

Check the cards, reference data and quantities against this requisition. Keep the staff answer guide separate until the checking stage. Supplied numerical practice datasets are labelled examples; they are not class measurements.

Answers and teaching notes

Expected explanations • do not give as experimental observations

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• A/B: chip size changes; acid concentration/volume, marble mass and temperature are controlled. A/C: concentration changes with chip size fixed. Gas volume over time is measured in both.

• Use the plotted early gradient Δvolume/Δtime; report units $cm^3\ s^{-1}$. No numerical rate is specified because the class supplies the measurements.

• Smaller pieces of the same mass expose more surface for collisions with acid particles, usually increasing the rate.

• Higher concentration means more reacting particles per unit volume and more frequent successful collisions at the same temperature; their average kinetic energy is not increased by concentration alone.

• The same limiting marble mass can produce a similar final amount of CO_2 if acid is in excess and reaction completes. A three-minute reading need not be the final volume.

• Gas loss before bunging and leaks reduce readings; syringe friction and chip variability affect curves. Use prompt consistent bunging, checked apparatus, repeats and matched chip fractions; do not hide anomalous raw data.

References and provenance

Pearson Chemistry specification

RSC teaching marble/acid rate investigations

Prepared 22 November 2026. Original wording, tables and questions. Sources inform the concepts and technique; the lesson scope and classroom quantities are explicitly described here. No laboratory trial or final school risk approval is claimed.