Ionic lattices

Teacher / technician preparation • separate staff-only edition

YEAR 10 / LESSON 17 / CHEMISTRY + SCIENCE (DOUBLE AWARD)

Staff use only; keep separate from student copies. This document is not a local risk assessment or classroom authorisation. No local physical validation is claimed. Complete normal teacher/technician pre-lesson checks and follow the employer's risk assessment before use.

Scope and course coverage

Year 10 Chemistry and Science (Double Award). 1.43 is investigated for solid and aqueous states only. Molten conduction is not demonstrated. 1.42 high melting and boiling points are model-based discussion, not measurements. This investigation measures conduction; it does not investigate, identify or collect electrolysis products. Brief DC may cause electrode reactions; this activity identifies no product and makes no claim that such reactions are impossible.

Requisition • ten groups of up to three

Eye protection: one pair per student. Per group: 27 modelling balls, preferably two sizes (smaller Na^+, larger Cl^-); 54 nearest-neighbour connectors PLUS spares, for example a counted bundle of 60; counting tray/bag. A complete cube uses 18 connectors along each of three axes: 2 gaps × 9 lines × 3 axes = 54. Require every issued stick back.

The finite cube has 27 positions, with counts 14:13 if corners are one type. It does not determine the 1:1 formula of the extended NaCl lattice. If one size of ball is issued, record that limitation. If 54 plus spares are unavailable, obtain them or explicitly use a smaller complete-neighbour model and state the limitation; never silently claim completeness.

Per group: maximum 6.0 V DC pack; series 6 V lamp OR LED with suitable series resistor; leads and two graphite electrodes marked at 1.0 cm; OR a school conductivity meter with its own instructions. Suitable vessels for 20.0 cm^3 portions, labelled water / NaCl(aq) / sucrose(aq); clean dry watch glasses or small solid vessels; 25/50 cm^3 cylinder; water wash bottle; dry NaCl and sucrose pots with individual dry spatulas; at least 25 cm^3 of each 0.10 mol dm^{-3} solution; paper towel and labelled waste beaker.

Do not issue ethanol, copper(II) sulfate, potassium iodide or molten-salt apparatus for this activity. No flames. Sharp sticks: eye protection, point-down handling and full count-back. Do not prescribe product collection, sniffing or identification.

Solutions and pre-lesson setup

Staff preparation only • ordinary checks, not completed validation

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Prepare and label the actual 0.10 mol dm^{-3} solutions

M(NaCl) = 22.99 + 35.45 = 58.44 g mol^{-1}. For 1.00 dm^3 of 0.10 mol dm^{-3}, mass = 0.10 × 1.00 × 58.44 = 5.844 g; weigh 5.84 g and make up to 1.00 dm^3 with distilled or deionised water. 10 × 20.0 cm^3 = 200 cm^3 plus rinsing and a repeat; 1.00 dm^3 is sufficient.

M($C_{12}H_{22}O_{11}$) = (12 × 12.01) + (22 × 1.008) + (11 × 16.00) = 342.30 g mol^{-1} (using 1.01 for H gives 342.34; either way weigh 34.2 g). Mass = 0.10 × 1.00 × 342.3 = 34.23 g; weigh 34.2 g and make up to 1.00 dm^3.

At least 1 dm^3 for 20.0 cm^3 tests plus rinsing; 2 dm^3 is more comfortable.

Label each bottle with name, formula, concentration and “for conductivity tests — Lesson 17”. Do not leave unlabelled beakers of clear liquid. The chosen concentration and 20.0 cm^3 portions are local reproducibility choices, not a single official IGCSE/RSC requisition.

Electrical checks and genuine positive control

Maximum 6.0 V DC only; no mains. Use a 6 V lamp in series with the sample, or an LED with a suitable series resistor, so the circuit is current-limited. Keep the supply dry. Switch OFF before handling, moving or rinsing contacts. Use clean, dry contacts. Probes must not touch except for a brief lamp-tester function check.

Lamp-in-series function check: briefly touch electrodes together (lamp on), then separate (lamp off). This checks function, NOT sensitivity. A meter follows its own instructions; no universal probe-short or zero-in-air check, and never short an ammeter across the supply.

Positive control: test the ACTUAL issued 0.10 mol dm^{-3} NaCl solution in the issued vessel, at 1.0 cm spacing and 1.0 cm immersion clear of the base, to confirm a response. A short circuit does not test this sensitivity. These checks are ordinary pre-lesson practice and are not claimed as already performed.

Vessel geometry • disclose the local setup choice

Check 20.0 cm^3 in the chosen vessel: liquid depth must exceed 1.0 cm with base clearance. Electrodes remain 1.0 cm apart, immersed 1.0 cm and clear of walls/base. A wide 100 cm^3 beaker is not assumed. Use a boiling tube, narrow 25/50 cm^3 beaker or another checked vessel; if unsuitable, use a narrower vessel or agree and record an adjustment. No meter calibration data or response is supplied here.

Local vessel / measured depth / tester and positive-control check record:

Delivery and troubleshooting

No guaranteed readings • no electrolysis-product investigation

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Sequence and contamination control

Build and evaluate the model; count every stick back including unused spares before wet work unless retained on display. For conductivity: dry NaCl heap, dry sucrose heap, water, sucrose solution, then NaCl solution. Use 20.0 cm^3 for each liquid; control the 1.0 cm spacing and immersion. OFF before moving/rinsing. Rinse with distilled/deionised water and dry both electrodes between every sample; use clean vessels. Keep the supply dry. Run only long enough to record.

Troubleshooting • preserve observations

• Lamp never lights with electrodes touching: battery, lamp, loose lead, or the indicator not in series.

• Salt solution only dim or little meter response: electrodes too far apart, touching the base, insufficient immersion because the vessel is too wide for 20.0 cm^3, or a weak pack. Hold 1.0 cm spacing at the 1.0 cm mark, clear of the base, in a vessel of sufficient depth, and use the issued 0.10 mol dm^{-3} solution. Do not add random extra solid at the bench as an unofficial concentration change unless the teacher has authorised a fresh labelled batch. A probes-together short is not a substitute for the 0.10 mol dm^{-3} positive control.

• Sugar solution conducts: contaminated electrodes; rinse and dry thoroughly and retest a fresh 20.0 cm^3 portion; test sugar before salt if the order was reversed.

• Distilled water dim: impurities or dirty electrodes; record it; compare with the salt row; replace water from a freshly opened distilled container if the teacher so decides.

• Solid salt appears to conduct: electrodes touching each other, or a wet heap bridging them; dry the solid and keep the electrodes apart.

• Students ask about chlorine, electrolysis products, or the scheme's asthma note: use the fixed wording, 'This investigation measures conduction; it does not investigate, identify or collect electrolysis products.' Add that brief DC may cause electrode reactions, and that this practical neither identifies a product nor claims that such reactions are impossible. Do not copy the scheme sentence that chlorine is produced, and do not tell students that chlorine cannot form.

Waste and reset

Salt and sugar solutions may be diluted and poured to the sink under school procedure. Recover dry solids where practical. Count sticks. Rinse electrodes; remove batteries for long storage. Switch OFF before handling/rinsing. Do not pour heaps of dry solid into the sink. Wipe benches and wash hands. Apply the school’s disposal and local risk-assessment procedures.

Before classroom use: complete the local risk assessment; check actual samples, solution labels, tester response, electrode marks, vessel depth and model stock. No local physical validation is claimed. Keep the staff and student PDFs separate.

Interpretation and sources

Teaching guidance • do not issue this page to students

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Reasoning and limits

A lamp that lights, or a clearly higher meter reading than the water control, is evidence that the sample conducted in this circuit under these conditions. That supports the idea that the salt solution contains mobile ions. It does not, by itself, prove the identity of those ions, and it is not a measurement of conductivity in the molten state. This investigation measures conduction; it does not investigate, identify or collect electrolysis products. Brief DC may cause electrode reactions; do not treat a colour, smell or bubble, if one is noticed, as an identified product, and do not claim that such reactions cannot happen. A sugar solution that appears to conduct should be treated as possible contamination and retested after a thorough rinse; do not invent a reason that sugar ionises a bit. A dim lamp in distilled water may reflect impurities; record it and compare it with the salt-solution result rather than forcing the water row to off.

Use the model to discuss alternating charges, coordination 6 and many strong electrostatic forces throughout a giant lattice. The solid's ions are not free to move; dissolved ions can carry charge. A finite ball-and-stick model is not a molecule, is not to scale and can falsely imply directional covalent bonds. NaCl's extended 1:1 ratio is not inferred from the model's 14:13 count. Molten conduction and high melting points remain unmeasured.

Sources and pre-use checks

• Pearson Edexcel International GCSE Chemistry (2017 linear, 4CH1): 1.42–1.43, as recorded in scheme extracts. School worksheet / knowledge organiser support the model discussion.

• RSC / Nuffield, Which substances conduct electricity?: edu.rsc.org/experiments/which-substances-conduct-electricity/1789.article — 6 V, graphite electrodes and mobile-ion explanation; molten methods excluded.

• RSC, Using a microscale conductivity meter: edu.rsc.org/practical/using-a-microscale-conductivity-meter/540.article — sample types, not the selected volumes/concentration or universal meter checks.

• RSC solid-salt / salt-solution demonstration: edu.rsc.org/download?ac=537313 — continuous solid heap, lamp-function check, water impurities and clean electrodes.

• RSC, The electrolysis of solutions: edu.rsc.org/experiments/electrolysis/466.article — contrast only; product-identification/collection method is not used.

Source details and adaptations are recorded in the accompanying source notes. No fresh independent source verification or local physical validation is claimed. The 20.0 cm^3, 0.10 mol dm^{-3} and 1.0 cm geometry are disclosed reproducibility choices. Complete ordinary checks and the employer's assessment before teaching.

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