Ionic lattices

Model and electrical conductivity

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

The question

Why do ionic compounds conduct electricity when they are dissolved in water, but not when they are solid?

First you build a small cube to help you picture the giant ionic lattice in solid sodium chloride, and you note what the model does well and what it leaves out, including that a finite model does not determine the formula. Then you test whether solid salt, solid sugar, distilled water, salt solution and sugar solution complete a low-voltage series circuit. Record the lamp (or meter) you actually see. This practical does not melt an ionic compound, so it does not itself show conduction in the molten state. This investigation measures conduction; it does not investigate, identify or collect electrolysis products.

Course links: 1.43 — solid and aqueous states only; molten conduction is not tested. 1.42 — model-based discussion of high melting/boiling points; no melting or boiling point is measured.

Equipment • per group of up to three

Model: eye protection; 27 modelling balls for a 3 × 3 × 3 cube, in two sizes if available; 54 connectors plus spares (for example a counted bundle of 60); counting tray/bag. If only one ball size is issued, record that model limitation.

Conductivity: maximum 6.0 V DC pack with series 6 V lamp OR LED with suitable series resistor, leads and two graphite electrodes with 1.0 cm immersion marks; OR a school conductivity meter under its own instructions. Suitable labelled liquid vessels; clean dry watch glasses/solid vessels; 25/50 cm^3 measuring cylinder; distilled/deionised water wash bottle; dry NaCl and sucrose pots, each with its own dry spatula; at least 25 cm^3 each of staff-issued 0.10 mol dm^{-3} NaCl(aq) and sucrose(aq); paper towel; labelled waste beaker.

The vessel is a local setup choice: 20.0 cm^3 must give a liquid depth greater than 1.0 cm plus base clearance. Electrode tips must remain clear of base and walls. A wide 100 cm^3 beaker is not assumed; use the suitable vessel issued by your teacher (for example a boiling tube or narrow 25/50 cm^3 beaker). Record its type and the depth if provided.

Safety throughout

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.

Wear eye protection. Carry sharp cocktail sticks point-down; do not wave them or put them in your mouth; report punctures. Salt and sugar are low hazard, but avoid dust in eyes; wipe spills and do not taste. No flames or ethanol. Brief DC may cause electrode reactions: do not sniff electrodes/solutions or try to name or collect products. Follow the school's risk assessment.

Part A • build an ionic model

A finite model does not determine a chemical formula

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

1. Read the ion labels. If two sizes are issued, smaller balls represent Na^+ and larger balls represent Cl^-.

2. Join one sodium ion to two chloride ions in a straight line.

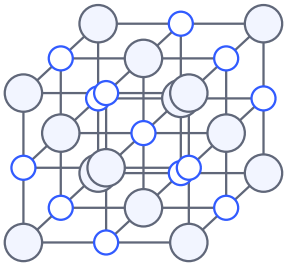
3. Join two more chloride ions to that sodium ion: four chloride ions now form a planar cross, with angles of 90°.

4. Add two more chloride ions in front and behind that sodium ion, giving six neighbours at 90°. This represents coordination 6 in solid NaCl.

5. Continue the alternating cubic pattern until there are three ions along each edge. Join every nearest-neighbour pair: a complete 3 × 3 × 3 uses 54 connectors, 18 along each axis. Use spares only for broken sticks.

6. Your cube has 27 positions. If all corners are one ion type, it has 14 of one ion and 13 of the other. Do not use this finite count as the formula: the extended lattice has the 1:1 formula NaCl.

7. Record the model details below. Dismantle carefully and return the whole counted bundle, including unused spares, before Part B unless your teacher asks you to leave the model on display.



3 × 3 × 3 positions

27 ion positions • 54 nearest-neighbour connectors

Small balls: Na^+ Large balls: Cl^-

Sticks show connections, not covalent bonds.

Schematic, not to scale; finite counts are not a formula.

Model record	Your model
Ions along each edge; every nearest-neighbour joined?	
Connectors used; whole bundle returned	
Ion counts (if counted); two ball sizes available?	

Write one strength and at least two limitations in the analysis on page 5. Sticks can misleadingly suggest covalent bonds; sizes may not be to scale; a tiny finite cube is not a whole giant lattice.

Part B • measure conduction

Same geometry • clean electrodes • sugar solution before salt solution

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

For every liquid: 20.0 cm^3; electrodes 1.0 cm apart and immersed to 1.0 cm, clear of the base and walls. Switch OFF before moving or rinsing. Rinse both electrodes with distilled/deionised water and dry with paper towel between EVERY sample. Keep the supply dry; use clean, dry contacts.

1. Record tester type and set potential (maximum 6.0 V DC) or meter identity. Lamp-in-series tester ONLY: briefly touch electrodes together; the lamp should light, then go off when separated. Report a fault. This is a function check, not a sensitivity test of the 0.10 mol dm^{-3} solution. For a meter follow its own instructions; do not short or zero in air unless instructed for that instrument.

2. On a dry watch glass make a continuous dry heap of NaCl, with grains touching between the electrodes. Press electrodes into it 1.0 cm apart; they must not touch. Switch on briefly, record off/dim/bright OR meter reading and unit, then switch OFF.

3. Rinse and dry electrodes. Repeat with a dry sugar heap on a clean dry watch glass.

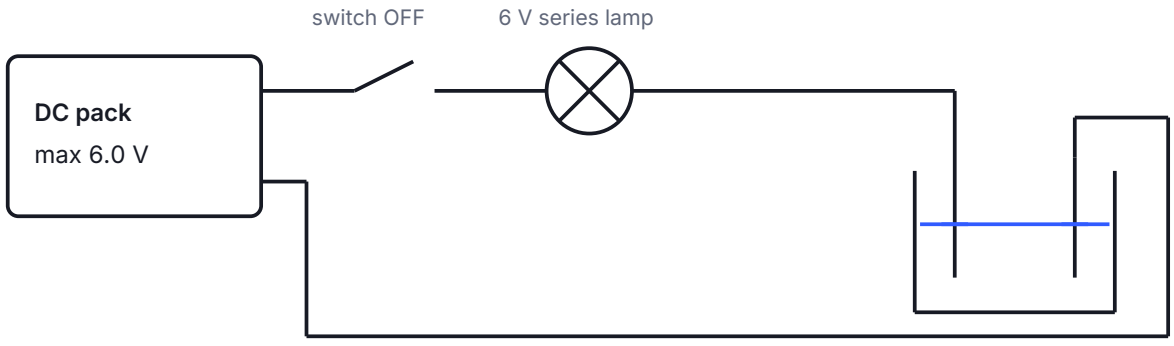
4. Measure 20.0 cm^3 distilled/deionised water into the clean issued vessel. Test at the controlled geometry: switch on, record, switch OFF. Record a dim result honestly; impurities may allow some conduction.

5. Test 20.0 cm^3 of 0.10 mol dm^{-3} sucrose solution in a clean vessel with the same geometry, BEFORE salt solution. A reused water vessel must be rinsed, distilled-water-washed and emptied. Record, then switch OFF.

6. Rinse and dry thoroughly. Test 20.0 cm^3 of 0.10 mol dm^{-3} NaCl solution in a clean issued vessel in the same way; record and switch OFF.

7. If unclear, switch OFF, rinse and dry, take a fresh 20.0 cm^3 portion, and record both readings. Do not force an expected brightness. Collect solutions in labelled waste and return unused dry solids.

This investigation measures conduction; it does not investigate, identify or collect electrolysis products. Do not run the circuit longer than needed to record the lamp or meter.



1.0 cm apart • 1.0 cm immersion

20.0 cm^3 in a suitable narrow vessel; ends clear of base and walls.

Results and cleanup

Table B • actual observations only; no invented readings

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

Tester / meter identity, set voltage (if applicable) and unit:

Local vessel type and measured depth of 20.0 cm^3, if supplied:

Sample / state	Portion	Vessel used	Electrode geometry	Lamp off / dim / bright OR reading + unit
Sodium chloride / solid	Dry heap		1.0 cm apart, into heap	
Sucrose / solid	Dry heap		1.0 cm apart, into heap	
Distilled / deionised water / liquid	20.0 cm^3		1.0 cm apart; 1.0 cm immersed	
Sucrose solution / aqueous, 0.10 mol dm^{-3}	20.0 cm^3		Same liquid geometry	
NaCl solution / aqueous, 0.10 mol dm^{-3}	20.0 cm^3		Same liquid geometry	

Repeated / uncertain observations (identify sample and keep both readings):

Cleanup

1. Pour the used 20.0 cm^3 portions into the labelled waste beaker, then empty to the sink with plenty of water if the teacher so directs.

2. Return dry salt and sugar to their pots or recovery container. Do not pour heaps of solid into the sink.

3. Switch the pack off. Then rinse and dry graphite electrodes and vessels.

4. Dismantle any remaining model, count every cocktail stick back (54 used for a complete nearest-neighbour 3 × 3 × 3, plus unused spares), and pack the balls.

5. Wipe the bench and wash hands.

No graph is required. With a meter, an optional bar chart must use only your own readings, with the unit and sample labels.

Explain the model and results

Link claims to the model and your own evidence

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

1. Describe the arrangement of ions in your cube. What does 'giant ionic lattice' mean, and why do chemists not speak of 'one molecule of sodium chloride'? Why does counting the ions on a finite 3 × 3 × 3 cube (27 positions; 14 of one ion and 13 of the other if the corners are one type) not determine the formula?

2. State one advantage and two limitations of the ball-and-stick model you used. Include the point that a finite model does not determine the formula.

3. Using Table B, compare solid sodium chloride with sodium chloride solution. Explain the difference in terms of whether ions can move.

Evaluate the investigation

Separate measured evidence from explanations and untested states

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

4. Sugar dissolves in water but a clean sugar solution should not conduct in the same way as a salt solution. Explain why dissolving, by itself, is not enough for a substance to conduct, and say what you would do if your sugar solution lit the lamp.

5. This practical does not melt sodium chloride. What does specification point 1.43 also say about molten ionic compounds, and why is that statement not something your results can show by themselves? This investigation measures conduction; it does not investigate, identify or collect electrolysis products. Why can you not use this practical either to name an electrolysis product or to claim that electrode reactions are impossible?

6. Why do ionic compounds typically have high melting points? Use the idea of many strong electrostatic forces in the giant lattice. Say clearly that you did not measure a melting point in this lesson.

Interpret cautiously: a lamp that lights or a clearly higher reading than the water control supports conduction under these conditions, not ion identity. A dim water reading may reflect impurities. Unexpected conduction in sugar solution needs a contamination check and a fresh portion, not a claim that sugar ionises.

Sources: Pearson Edexcel International GCSE Chemistry (2017), 1.42–1.43; RSC / Nuffield, Which substances conduct electricity?; RSC, Using a microscale conductivity meter and solid-salt / salt-solution demonstration notes. The 0.10 mol dm^{-3}, 20.0 cm^3 and electrode geometry are local reproducibility choices, not a single official requisition.