

Which Structure Is It, and Which Job Can It Do?

Investigation question: Using what a hand lens and a simple test show, plus what counting atoms in fragments reveals, which type of structure is each everyday solid, and which one should you choose for a job?

Data-driven decision

Groups of 4

1 session

Setup 8 · Activity 40 · Cleanup 5 min

MS-PS1-1 · practice

Name _____

Group _____

Date _____

Your role today

- ☐ **Observer:** Uses the hand lens at each station, describes grain shape and surface in words, and runs the crush, rub or stretch test exactly as the station card says.
- ☐ **Data reader:** Reads the fragment-count data card aloud, states whether the counts grow or stay the same, and works out the ratio or the fixed count.
- ☐ **Recorder:** Fills the station table and the data-card table for the group, and makes sure each row has evidence from both sources before moving on.
- ☐ **Decision lead:** Runs the decision matrix at the end: proposes a structure-type card for each substance, asks the group for two pieces of evidence, and manages the job choices.

Safety

- Nothing at the stations may be tasted, even salt and sugar; they have been handled by many people.
- Do the crush test inside the folded paper pocket so grains of sand or salt cannot fly toward eyes. Press, do not strike.
- Do not blow on the sand or salt; fine dust is a breathing irritant. Wipe the station with a damp towel at the end.
- Keep hand lenses away from direct sunlight; a lens can focus the sun into a hot spot on paper or skin.
- Plastic bag strips are small, but whole bags stay in the supply box; no bags over heads or faces.
- Wash hands after the lab, especially after the graphite station.

Procedure

1. Read all seven structure-type cards as a group before visiting any station, so you know what you are looking for. Note that one card may not match any substance.
2. At each station, the observer looks at a pinch of material through the hand lens on black paper and describes the shape of the grains (or the surface) in words, then runs the station's test: press with the spoon inside the paper pocket (salt, sugar, sand), rub on paper and smear with a finger (graphite), or pull slowly from both ends (bag strip).
3. The recorder writes the shape, the test result and one word for how the material behaved in the station table. Everyone looks before the group moves on; take about five minutes per station.

4. At each station the data reader reads the substance's fragment-count card. Decide together: do the counts stay the same from fragment to fragment, or do they grow? If they grow, work out the ratio in simplest form; if they stay the same, write the fixed count. Note the number of bonds per atom reported on the card.
5. Record the data-card reading in the data table. Then rotate to the next station until all five are done.
6. Back at your seats, read the sixth data card, diamond, which has no station. Fill its data row from the card alone.
7. Run the decision matrix: for each of the six substances, choose the structure-type card that fits and write two pieces of evidence, one from the station (or the card's described behavior, for diamond) and one from the fragment counts. Mark which type card was left unmatched.
8. Choose a material for each of the three jobs in the job table. For each job, name the material and write one sentence that uses its structure as the reason.
9. Answer q1 and q2 on the sheet, then complete the analysis questions individually.

Record your observations

Lab 2 recording sheet: Which structure, which job?

You will collect two kinds of evidence for each substance: what you can see and test at the station, and what a teaching data card says about the atoms in fragments of different sizes. Both kinds go into your decision.

Station observations

Station	Substance	Grain or surface shape under the lens	Test (crush, rub or stretch) and what happened	One word for how it behaved
1	Table salt			
2	Granulated sugar			
3	Pencil graphite			
4	Polyethylene bag strip			
5	Quartz sand			

Fragment-count data cards (teaching dataset)

Simulated teaching dataset: the numbers are invented to be realistic, not measured.

Substance	Fragment 1	Fragment 2	Fragment 3	Bonds per atom reported	Other note on the card
Table salt	6 Na, 6 Cl	20 Na, 20 Cl	150 Na, 150 Cl	each particle touches 6 of the other kind	pattern repeats at right angles in all directions
Granulated sugar	12 C, 22 H, 11 O	12 C, 22 H, 11 O	12 C, 22 H, 11 O	C 4, O 2, H 1 within the particle	a grain holds billions of these 45-atom particles stacked in a slanted repeating pattern
Pencil graphite	50 C	400 C	9,000 C	3, all in one flat sheet	sheets stack with only weak attraction between them
Polyethylene bag	30 C, 60 H	200 C, 400 H	5,000 C, 10,000 H	C 4 (2 to carbons, 2 to hydrogens), H 1	atoms form long chains that can slide past and line up with each other
Quartz sand	10 Si, 20 O	48 Si, 96 O	300 Si, 600 O	Si 4, O 2	every silicon joins 4 oxygens and every oxygen joins 2 silicons, in all directions
Diamond (card only)	50 C	400 C	9,000 C	4, pointing in different directions	one rigid network in all directions; the hardest natural material

This is a teaching dataset: the fragment counts are invented to mirror real substances. The bonds-per-atom and pattern notes match the real structures.

Structure-type cards

Card 1

Type A. Small molecule, loose: particles with a definite count of atoms (for example 3 or 5) that move freely as a liquid or gas at room temperature; no repeating pattern.

Card 2

Type B. Molecular crystal: molecules with a definite count of atoms, stacked in a repeating pattern; strong bonds inside each molecule, weak attraction between molecules.

Card 3

Type C. Two-element crystal, right-angle pattern: two kinds of particles alternating in a fixed 1:1 ratio, repeating in all directions; no molecules.

Card 4

Type D. Layered crystal of one element: each atom bonded to 3 neighbors in a flat sheet; sheets stacked with only weak attraction between them.

Card 5

Type E. Network crystal of one element: each atom bonded to 4 neighbors pointing in different directions; one rigid structure in all directions.

Card 6

Type F. Two-element network crystal, 1:2 ratio: every atom of one element bonded to 4 of the other, every atom of the other bonded to 2 of the first; rigid in all directions.

Card 7

Type G. Polymer: one small unit repeated thousands of times in a long chain; chains can slide past and line up with each other.

Data-card reading

Substance	Do the counts stay the same or grow?	Fixed count or ratio (simplest form)	Molecule or extended structure?	Bonds per atom
Table salt				
Granulated sugar				
Pencil graphite				
Polyethylene bag				
Quartz sand				
Diamond				

Decision matrix

Substance	Structure-type card (letter)	Evidence from the station or described behavior	Evidence from the fragment counts
Table salt			
Granulated sugar			
Pencil graphite			
Polyethylene bag			
Quartz sand			
Diamond			
Unmatched type card:			

Choose a material for the job

Job	Material chosen	Reason that uses its structure
Job 1: leaves a mark on paper that can be rubbed off		
Job 2: a light strap that stretches a little and does not shatter		
Job 3: the tip of a drill for cutting stone and concrete		

1. Which structure-type card did not match any substance? What kind of substance would match it, and why could it not be at a station like the others?

2. Which substance was hardest to place, and which piece of evidence finally decided it?

Analysis questions

3. Graphite and diamond have identical fragment counts on their data cards. What evidence told you they are different structures, and what would happen if someone used a diamond chip as a pencil?

4. Sugar is the only substance whose fragment counts never changed and whose grains are still crystals. Explain how a sugar grain can be made of molecules and still be an extended structure.

5. A quartz fragment is found to contain 720 oxygen atoms. How many silicon atoms does it hold? Show the ratio you used.

6. When you pulled the bag strip, it narrowed and turned whitish but did not snap back. Use the polymer structure card to explain what the chains inside were doing.

7. Explain your choice for Job 3 (the drill tip). Then say why salt, which also has a rigid repeating pattern, would be a poor choice for the same job.

8. The fragment-count cards were invented for teaching. What could a real laboratory measure to test whether a solid is a molecule or an extended structure, and what is one thing the hand-lens observations could not tell you?
