

Count or Ratio? Building Molecules and a Salt Block

Investigation question: What does a chemical formula actually count, and why does the answer change when you build table salt instead of water?

Physical model

Groups of 3

1 session

Setup 5 · Activity 40 · Cleanup 5 min

MS-PS1-1 · assesses

Name _____

Group _____

Date _____

Your role today

- ☐ **Builder:** Assembles each model following the color key and the bond rule, and keeps finished models on the tray until they have been counted.
- ☐ **Checker:** Counts every sphere by color and every stick before a model is recorded, checks that each gumdrop has the right number of toothpicks, and calls out the counts.
- ☐ **Recorder:** Writes the counts, formula and shape in the build record, sketches the butane and isobutane skeletons, and fills the salt-block table.

Safety

- Toothpick points can puncture skin and eyes. Hold models at desk level, never wave them, and drop used toothpicks into the cup, not on the floor.
- No eating any material. Candy that has been handled and pierced is not food; some students have gelatin, dye or sugar restrictions, and shared candy spreads germs.
- Wash hands after the lab; gumdrop sugar on hands transfers to keyboards and door handles.
- Broken toothpick halves are sharp; snap them inside the cup or under a paper towel.

Procedure

1. Read the color key and the bond rule: hydrogen takes 1 toothpick, oxygen 2, nitrogen 3, carbon 4. One toothpick between two gumdrops is one bond. For oxygen gas and carbon dioxide, use two toothpicks side by side between the same pair to stand for a double bond.
2. Build water: one red, two white, each white joined to the red by one toothpick. Make the two toothpicks meet at the red in a wide V, not a straight line. Count spheres by color, count bonds, write the formula and shape in the build record.
3. Build oxygen gas (two red joined by two side-by-side toothpicks) and carbon dioxide (one black in the middle, a red on each side joined by double toothpicks, all in a straight line). Record both.
4. Build methane (one black with four whites, pointing to the corners of a pyramid, not flat) and ammonia (one blue with three whites, a shallow pyramid). Record both. Keep every model on the tray for now.
5. Build hydrogen peroxide: white-red-red-white in a chain, one toothpick per bond. Set it next to water, compare the two, and record. Then take water, oxygen gas, carbon dioxide, methane and ammonia apart,

returning toothpicks to the cup; keep only hydrogen peroxide on the tray. You will need the freed black and white gumdrops for butane.

6. Build butane: four blacks in a row joined by single toothpicks. Add whites until every black has exactly four toothpicks. Count the whites. Record. Now take it apart and build isobutane: one black in the center joined to three other blacks, then add whites until every black has four toothpicks. Count the whites. Record both, and draw both carbon skeletons in the drawing box.
7. Start the salt block. Lay out a 2-by-2 square: purple, green on the first row, green, purple on the second, so every neighbor is the other color. Join neighbors with half toothpicks. Count each color and record the row for the 2-by-2 layer.
8. Build a second 2-by-2 layer with the colors swapped and set it on top so every purple sits above a green. Join the layers with half toothpicks. You now have a 2-by-2-by-2 cube. Count each color, record, and write the ratio in simplest form.
9. Enlarge the block: add a column to make 3-by-2-by-2, then another row to make 3-by-3-by-2, always keeping every neighbor the other color. Count and record after each size. If time allows, build one more size of your choice.
10. Look at your two tables. Decide for each build whether the formula is a count (the same every time) or a ratio (the totals change but the proportion does not). Answer q1 and q2 on the sheet, then the analysis questions on your own.

Record your observations

Lab 1 recording sheet: Count or ratio?

Record every build after the checker has counted it. Count spheres by color for the composition and toothpicks between pairs for the bonds (a side-by-side pair of toothpicks is one double bond). Write the formula from your count, not from memory.

Color key and bond rule — White = hydrogen (1 toothpick). Red = oxygen (2). Blue = nitrogen (3). Black = carbon (4). Purple = sodium particle and green = chlorine particle, salt block only, each connects only to the other color. Colors are a labeling habit, not the real color of atoms.

Molecule builds

Molecule	Atoms of each element (from your model)	Total atoms	Number of bonds	Formula	Shape (bent, straight, pyramid, chain, branch)
Water					
Oxygen gas					
Carbon dioxide					
Methane					
Ammonia					
Hydrogen peroxide					
Butane					
Isobutane					

-  Draw the carbon skeletons of butane and isobutane side by side as circles and lines (carbons only). Next to each carbon write how many hydrogens it holds, and check that the hydrogens add to 10 in both.

Salt block builds

Block size	Purple (Na) count	Green (Cl) count	Total particles	Ratio Na : Cl in simplest form
2 by 2 layer				
2 by 2 by 2 cube				
3 by 2 by 2				
3 by 3 by 2				
Your choice: ____				

1. Which builds gave the same count every time, and which build could you have kept making bigger? Name them.

2. Look at the ratio column of the salt table. What stayed the same as the block grew, and what changed?

Analysis questions

3. Water and hydrogen peroxide use the same two colors of gumdrops. Using your build record, explain what makes them different substances.

4. Butane and isobutane used exactly the same gumdrops: four black and ten white. Using your drawing, explain what makes them different substances.

5. Suppose you built a 4-by-4-by-4 salt block with every neighbor the other color. How many purple, how many green, what total, and what ratio? Show your reasoning.

6. The formula H_2O and the formula NaCl look alike, but they mean different things. Using numbers from both of your tables, explain what each formula counts and why the salt formula has no small numbers.

7. A classmate looks at your 3-by-3-by-2 block and says, 'That is a bigger molecule of salt.' Write a reply that uses the words molecule, extended structure and ratio correctly.

8. Name two ways the gumdrop model does not match real atoms and bonds, and one thing the model shows well.

9. Quartz is silicon and oxygen in a 1:2 ratio. If you built a quartz model with 24 silicon gumdrops, how many oxygen gumdrops would it need? If your bag held only 40 oxygen gumdrops, what is the largest number of silicon gumdrops you could use? Show the arithmetic.
