

Build a Molecule — Chemical Formulas Lab Worksheet

Name: _____ Class: _____ Date: _____

Open the free **Build a Molecule** simulation by PhET (eolclassroom-online.com/classroom-simulations/ or phet.colorado.edu). Drag atoms out of the kit buckets and connect them to build molecules. Drop finished molecules into the collection boxes on the right. Use the arrows on the kit to see more atoms.

Part A — Read a formula (Single screen)

Build each molecule in Collection 1. When a molecule is complete, its name appears. Click **3D** to rotate it.

Formula	Name	Atoms of each element	Total atoms	Sketch of the structure
H ₂ O				
O ₂				
H ₂				
CO ₂				
N ₂				

1. In a chemical formula, what does the small number after a symbol (the **subscript**) tell you?

2. What does it mean when a symbol has no subscript, as for O in H₂O?

Part B — Subscripts vs coefficients (Multiple screen)

The collection boxes now show goals such as **2CO₂**. The large number in front is a **coefficient**.

Goal	Number of molecules	Atoms of each element in total
2CO ₂		
2O ₂		
4H ₂		

Goal	Number of molecules	Atoms of each element in total
2NH ₃		

3. What is the difference between a coefficient and a subscript?

4. How many hydrogen atoms are in **3H₂O**? Show your working.

5. **2H₂O** and **H₂O₂** both contain hydrogen and oxygen. Are they the same? Build both if you can and explain.

Part C — Bonding patterns

Look at the molecules you built and count how many bonds each type of atom makes.

Atom	Number of bonds it usually forms	Example molecule
Hydrogen (H)		
Oxygen (O)		
Nitrogen (N)		
Carbon (C)		

6. Use your table to predict the formula of the simplest molecule made of one carbon atom and hydrogen atoms. Then build it in the **Playground** and check its name.

7. Predict the formula for one nitrogen atom bonded to hydrogen atoms. Build it to check.

Part D — Playground challenges

Build each molecule in the **Playground** screen. Write its formula and number of atoms.

Name	Formula	Total atoms
Methane		
Ammonia		
Hydrogen peroxide		
Ozone		
Ethylene		

8. Ozone (O₃) and oxygen (O₂) are made of the same element. Why are they different substances?

Part E — Count atoms in a reaction

Hydrogen burns in oxygen to make water: **2H₂ + O₂ → 2H₂O**

9. Count the atoms on each side.

	Hydrogen atoms	Oxygen atoms
Left side (reactants)		
Right side (products)		

10. Why must the number of each type of atom be the same on both sides of a chemical equation?

Answer Key (Teacher Copy)

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Part A

Formula	Name	Atoms	Total
H ₂ O	water	2 H, 1 O	3
O ₂	molecular oxygen	2 O	2
H ₂	molecular hydrogen	2 H	2
CO ₂	carbon dioxide	1 C, 2 O	3
N ₂	molecular nitrogen	2 N	2

Structures: H-O-H (bent shape in 3D); O=O; H-H; O=C=O (straight line); N≡N.

1. The number of atoms of that element in one molecule.
2. There is one atom of that element.

Part B

Goal	Molecules	Atoms in total
2CO ₂	2	2 C, 4 O
2O ₂	2	4 O
4H ₂	4	8 H
2NH ₃	2	2 N, 6 H

3. A subscript tells you how many atoms are inside one molecule; changing it makes a different substance. A coefficient tells you how many whole molecules there are.
4. $3 \times 2 = \mathbf{6 \text{ hydrogen atoms}}$ (and 3 oxygen atoms).
5. No. 2H₂O is two water molecules (4 H and 2 O in total, as two separate molecules). H₂O₂ is one molecule of hydrogen peroxide (2 H and 2 O bonded together), a different substance with different properties.

Part C

Atom	Bonds	Example
Hydrogen	1	H ₂ , H ₂ O
Oxygen	2	H ₂ O, O ₂ (a double bond counts as 2)

Atom	Bonds	Example
Nitrogen	3	NH ₃ , N ₂ (a triple bond counts as 3)
Carbon	4	CH ₄ , CO ₂

6. **CH₄** (methane): carbon forms 4 bonds, one to each hydrogen.

7. **NH₃** (ammonia): nitrogen forms 3 bonds.

Part D

Name	Formula	Total atoms
Methane	CH ₄	5
Ammonia	NH ₃	4
Hydrogen peroxide	H ₂ O ₂	4
Ozone	O ₃	3
Ethylene	C ₂ H ₄	6

8. Their molecules contain different numbers of atoms (3 versus 2), so they have different structures and properties. For example, ozone in the upper atmosphere absorbs ultraviolet light, while O₂ is the oxygen we breathe.

Part E

	Hydrogen atoms	Oxygen atoms
Left side	4	2
Right side	4	2

10. Atoms are not created or destroyed in a chemical reaction; they are only rearranged into new molecules (the law of conservation of mass). So every atom on the left must appear on the right.