

Answer Key: Conservation of Mass in Chemical Reactions

Course: Chemistry (Grades 9–12) **Subject:** Science **For teacher use only** Science

How to use this key

Answers are grouped by section and question number. Many items are open-ended; accept any response that shows correct reasoning even if the wording differs. The mass calculations are worked out in full. Notes flag where more than one answer is defensible and list common misconceptions to watch for. A calculator is allowed but not required — all values divide and subtract cleanly. Estimated grading time: ~6–8 min per packet.

Start Notice & Wonder grade for effort · ~2 min

1 Where did the burned wood's material go?

Full credit for any reasonable notice + wonder. **Ideal:** Notice — "there is much less material left than the wood we started with." Wonder — "did the missing material turn into smoke or gas?" Accept any on-topic wonder. *Science note (not required from students):* the wood's atoms combined with oxygen and left as invisible gases (carbon dioxide and water vapor) plus smoke; mass was conserved, just not all left behind as ash.

2 Capped bottle before vs. after fizzing.

Accept any reasonable prior idea. **Target idea:** the total mass **stays the same**, because the bottle is **closed** — the gas (carbon dioxide) that forms is trapped inside, so no matter leaves. Do not penalize incorrect prior knowledge here — this is a warm-up. (A student who predicts a change is often revealing the "gas has no mass" or "open-system loss" misconception; note it for Q6/Q9.)

Build Read the Science ~1 min

3 Atom counts from Figure 1; were atoms conserved?

Before: 4 H atoms and 2 O atoms ($2\text{H}_2 = 4\text{H}$; $\text{O}_2 = 2\text{O}$). **After:** 4 H atoms and 2 O atoms ($2\text{H}_2\text{O} = 4\text{H}$ and 2 O). **Yes — atoms were conserved:** the same numbers of H and O appear on both sides; the atoms were only rearranged from H_2 and O_2 molecules into H_2O molecules. Since the same atoms are present, the total mass is unchanged.

Apply Use the Data ~3 min

4 Check conservation in Reaction 1 (worked).

Reactants: $12.0\text{ g} + 8.0\text{ g} = 20.0\text{ g}$. Product recovered = **20.0 g**. Since $20.0\text{ g} = 20.0\text{ g}$, **mass was conserved**. You can tell because the total mass of the reactants equals the total mass of the products — no mass was gained or lost in the sealed (closed) flask.

5 Find the missing mass, Reaction 2 (worked).

5a. mass of A + mass of B = total mass of products.

5b. $15.0\text{ g} + (\text{mass of B}) = 40.0\text{ g} \rightarrow \text{mass of B} = 40.0\text{ g} - 15.0\text{ g} = \mathbf{25.0\text{ g}}$. Reactant B had a mass of **25.0 g**. (Closed system, so all product mass came from the reactants.)

6 Explain the open system, Reaction 3 (worked).

6a. Missing mass = $50.0\text{ g} - 34.0\text{ g} = \mathbf{16.0\text{ g}}$.

6b. The 16.0 g was **not destroyed**. In this **open** beaker a **gas** product formed and escaped into the air, carrying those 16.0 g away where the balance could not weigh them. If the reaction had been done in a **closed** container, the trapped gas would have been weighed and the total would still be 50.0 g. The law of conservation of mass holds — the atoms left as gas rather than being destroyed. *Full credit for identifying escaping gas as the missing mass and stating the law is not broken.*

7 Count atoms to check the balance: $\text{CH}_4 + 2\text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O}$.

Element	Left (reactants)	Right (products)	Balanced?
Carbon (C)	1 (in CH_4)	1 (in CO_2)	yes
Hydrogen (H)	4 (in CH_4)	4 (2×2 in $2\text{H}_2\text{O}$)	yes
Oxygen (O)	4 (2×2 in 2O_2)	4 (2 in CO_2 + 2 in $2\text{H}_2\text{O}$)	yes

Every element matches on both sides, so the whole equation **IS balanced** — **circle YES**. (This is the combustion of methane; students do not need to name it.)

8 Observation (O) vs. Inference (I).

a) **O** — a value read directly from Table 1 (34.0 g solid left).

b) **I** — the 16.0 g of escaped gas is not a recorded value; it is reasoned out ($50.0 - 34.0$) using conservation of mass.

c) **O** — a value read directly (20.0 g product).

d) **I** — a conclusion reasoned from the law (25.0 g of B is calculated, not measured; the table shows a dash). *Observation = measured/read directly; inference = a conclusion reasoned from evidence.*

9 Closed vs. open — which is fair?

Full credit if the student explains that a **closed system** traps every **product** — including any **gas** — so the balance weighs all the matter that came from the **reactants**, letting you fairly test that reactant mass = product mass. In an **open** system a gas product can escape (mass seems to drop) or a gas can be pulled in from the air (mass seems to rise), so the weighing fools you even though atoms are conserved. **Model:** "A closed system is fair because no gas can leave or enter, so all the products stay to be weighed and equal the reactants. An open system can fool you because a gas product escapes (or gas is taken in), changing the weight on the balance even though no atoms were created or destroyed." Accept equivalent wording.

Explain CER (Q10) ~2 min

10 Was mass conserved in Reaction 1?

Model answer. Claim: Mass **was conserved** in Reaction 1. Evidence: (1) The two reactants had masses of 12.0 g and 8.0 g, a total of 20.0 g. (2) The product recovered from the sealed flask had a mass of 20.0 g. Reasoning: By the law of conservation of mass, matter is not created or destroyed in a reaction — the atoms of the reactants are only rearranged into the product. Because the flask was a closed system, no matter left or entered, so the total mass of the products (20.0 g) equals the total mass of the reactants ($12.0 + 8.0 = 20.0\text{ g}$), which is exactly what the data show.

Defensible alternates: A student may cite the closed-system condition as a piece of evidence, or contrast

Reaction 1 with the open Reaction 3. Accept any claim of "conserved" supported by two correct numeric mass values and sound conservation-of-mass reasoning. A claim of "not conserved" is **incorrect** for Reaction 1 (the masses are equal) and should not earn full credit.

CER scoring rubric (3 points)

Score	Claim	Evidence	Reasoning
3	Clear, correct claim: mass was conserved in Reaction 1.	Two accurate mass values from Table 1 (e.g., 12.0 + 8.0 g reactants and 20.0 g product).	Correctly uses conservation of mass / rearranged atoms and the closed system to explain why reactant mass = product mass.
2	Correct claim stated, mostly clear.	One solid mass value, or two with a minor error.	Some correct linkage but incomplete or a small misconception.
1	Vague or partly correct claim.	Evidence weak, non-numeric, or not from the table.	Little or flawed reasoning; law not correctly applied.
0	No claim, or an incorrect "not conserved" claim.	No evidence.	No reasoning.

Close ACE ~1 min

ACE Articulate / Connect / Extend.

Articulate: accept any accurate plain-language statement (e.g., "in a reaction, atoms are not created or destroyed — they just rearrange, so the total mass of the products equals the total mass of the reactants").

Connect: the cited row must show conservation or an apparent change, e.g., Reaction 1: 12.0 + 8.0 g = 20.0 g product (conserved), or Reaction 3: 50.0 g → 34.0 g solid (16.0 g left as gas).

Extend: any correct new example, e.g., a rusting nail gains mass because iron takes in oxygen gas from the air; a fizzing open soda loses mass because carbon dioxide gas escapes; a burning candle in open air seems to lose mass but the atoms leave as gases. More than one answer is defensible; the key is that atoms are conserved and only the weighable mass changed.

Extend Early finisher & block extension (optional)

EF Design your own conservation problem.

Reward a sealed-flask reaction where the chosen masses obey reactants = products (for example 10 g + 5 g → 15 g) with exactly one value left blank that can be recovered by adding or subtracting. The solution must use the law of conservation of mass correctly to fill the blank.

Block Balance $\text{H}_2 + \text{O}_2 \rightarrow \text{H}_2\text{O}$ with coefficients (worked).

Balanced equation: $2 \text{H}_2 + \text{O}_2 \rightarrow 2 \text{H}_2\text{O}$ (coefficients 2, 1, 2).

Element Left Right

H $2 \times 2 = 4$ $2 \times 2 = 4$

O $1 \times 2 = 2$ $2 \times 1 = 2$

H: 4 = 4 and O: 2 = 2, so the equation is balanced. *Accept any equivalent whole-number multiple written in lowest terms (2, 1, 2 is the standard lowest-terms answer; $4 \text{H}_2 + 2 \text{O}_2 \rightarrow 4 \text{H}_2\text{O}$ is balanced but not lowest terms — note this if it appears).* A balanced equation shows conservation of mass because the same number of atoms of each element appears on both sides, so the reactant mass equals the product mass.

Watch Common misconceptions

- **"Mass (or matter) is created or destroyed in a reaction."** Atoms are never created or destroyed — they are only **rearranged**. New substances form, but the same atoms are present before and after, so the total mass is unchanged.
- **"Gases have no mass / don't count."** Gases have mass just like solids and liquids. In Reaction 3 the "missing" 16.0 g is the mass of the escaped **gas**. Watch for students who ignore gas when checking conservation.
- **"An open-system mass loss (or gain) breaks the law."** The law still holds; the container simply cannot weigh matter that has left as gas (mass seems to drop) or been pulled in from the air (mass seems to rise). A closed system reveals the true conservation.
- **Confusing coefficients and subscripts (Q7, Block).** A **coefficient** (big number in front) multiplies the whole particle; a **subscript** (small low number) counts atoms inside one particle. In $2 \text{ H}_2\text{O}$ the atoms are $2 \times 2 = 4 \text{ H}$ and $2 \times 1 = 2 \text{ O}$.
- **Observation vs. inference (Q8).** Students often mark a *calculated* value (escaped gas, missing reactant) as an "observation." If a number is reasoned out with the law rather than read from the table, it is an inference.

Teacher follow-up based on likely errors

If many students say mass was destroyed in the open beaker (Reaction 3), do a quick 5-minute discussion contrasting a sealed bottle with an open one and point to the escaped gas. If the missing-mass subtraction in Q5 is shaky, model reactants = products aloud with units. If Q7 atom counts are off, review that a coefficient multiplies the whole formula while a subscript counts atoms inside it. If CER (Q10) evidence is non-numeric, model citing the $12.0 + 8.0 = 20.0 \text{ g}$ contrast. The "mass is destroyed" and "gas has no mass" misconceptions are the highest-value items to address next class.