

Atoms and Mass

Connect atom counts, mole ratios, and conserved mass.

HIGH SCHOOL · HS-PS1-7

HS-PS1-7 "Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. Clarification Statement: Emphasis is on using mathematical ideas to communicate the proportional relationships..."

NAME _____

DATE _____

MASS STAYS ACCOUNTED FOR

A balanced equation preserves the number of each kind of atom. Its coefficients also give mole ratios. Mass = amount in mol $\times$ molar mass in g/mol. All calculations here assume the stated reaction goes to completion, with the stated reactant amounts in the balanced ratio and all products accounted for; rounded atomic molar masses are supplied.

WORKED EXAMPLE

For $2\text{Al} + 3\text{S} \rightarrow \text{Al}_2\text{S}_3$, count atoms in the equation, then compare masses for 2 mol Al and 3 mol S. Use Al = 27 g/mol and S = 32 g/mol.

ATOMS IN THE BALANCED EQUATION

Element	Left	Right
Al	2	2
S	3	3

1. The table shows equal Al and S atom counts on both sides.
2. $2 \text{ mol Al} \times 27 \text{ g/mol} = 54 \text{ g}$; $3 \text{ mol S} \times 32 \text{ g/mol} = 96 \text{ g}$.
3. 1 mol Al_2S_3 has mass $1 \text{ mol} \times [2(27) + 3(32)] \text{ g/mol} = 150 \text{ g}$.
4. $54 \text{ g} + 96 \text{ g} = 150 \text{ g}$; scaling atom ratios to moles preserves total mass.

Answer: 150 g of reactants = 150 g of product.

PRACTICE 4 problems

- 1** For $2\text{Mg} + \text{O}_2 \rightarrow 2\text{MgO}$, use 2 mol Mg and 1 mol O_2 . Mg = 24 g/mol; O = 16 g/mol. Count each kind of atom in the equation and compare total masses.

ANSWER _____

- 3** For $4\text{Li} + \text{O}_2 \rightarrow 2\text{Li}_2\text{O}$, use 4 mol Li and 1 mol O_2 . Li = 7 g/mol; O = 16 g/mol. Compare masses and explain the atom counts.

ANSWER _____

- 2** For $\text{C} + \text{O}_2 \rightarrow \text{CO}_2$, C = 12 g/mol and O = 16 g/mol. How many grams of CO_2 form from 1 mol C and 1 mol O_2 ?

ANSWER _____

- 4** $\text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2$. A model starts with 100 g CaCO_3 and forms 56 g CaO. Find the CO_2 mass. Explain why the solid residue alone is lighter.

ANSWER _____

APPLY IT Show your work

- 1** In a hypothetical closed-system calculation, 2 mol NaHCO_3 fully decomposes: $2\text{NaHCO}_3 \rightarrow \text{Na}_2\text{CO}_3 + \text{H}_2\text{O} + \text{CO}_2$. Find the missing mass and verify the C and O atom counts.

CALCULATED MASS ACCOUNTING

Substance	Mass
2 mol NaHCO_3	168 g
Na_2CO_3	106 g
H_2O	18 g
CO_2	?

ANSWER _____

- 2** A model of iron oxidation uses $4\text{Fe} + 3\text{O}_2 \rightarrow 2\text{Fe}_2\text{O}_3$. All 224 g Fe reacts with 96 g O_2 . Fe = 56 g/mol; O = 16 g/mol. Find the product mass and amount in moles. Explain why the product weighs more than the iron alone.

WORK SPACE

ANSWER _____

CHALLENGE One step up

A model completely reacts 56 g N_2 with 12 g H_2 : $\text{N}_2 + 3\text{H}_2 \rightarrow 2\text{NH}_3$. N = 14 g/mol; H = 1 g/mol. Find the mass and moles of NH_3 . Support conservation using both atom counts and mass.

WORK SPACE AND ANSWER

PART 1 • PRACTICE

#	PROBLEM	ANSWER
1	For $2\text{Mg} + \text{O}_2 \rightarrow 2\text{MgO}$, use 2 mol Mg and 1 mol O_2 . Mg = 24 g/mol; O = 16 g/mol. Count each kind of atom in the equation and compare total masses.	Mg: 2 atoms each side; O: 2 each side. Reactants: $2(24) + 32 = 80$ g. Products: $2(24 + 16) = 80$ g.
2	For $\text{C} + \text{O}_2 \rightarrow \text{CO}_2$, C = 12 g/mol and O = 16 g/mol. How many grams of CO_2 form from 1 mol C and 1 mol O_2 ?	1 mol CO_2 forms: $12 \text{ g} + 32 \text{ g} = 44 \text{ g}$. C: 1 atom each side; O: 2 each side.
3	For $4\text{Li} + \text{O}_2 \rightarrow 2\text{Li}_2\text{O}$, use 4 mol Li and 1 mol O_2 . Li = 7 g/mol; O = 16 g/mol. Compare masses and explain the atom counts.	Reactants: $4(7) + 32 = 60 \text{ g}$. Products: $2[2(7) + 16] = 60 \text{ g}$. Li: 4 atoms each side; O: 2 each side.
4	$\text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2$. A model starts with 100 g CaCO_3 and forms 56 g CaO. Find the CO_2 mass. Explain why the solid residue alone is lighter.	44 g CO_2. The other 44 g is in the gaseous product; total matter has not disappeared.

PART 2 • APPLY IT

- 44 g CO_2** $168 - 106 - 18 = 44 \text{ g}$. C: 2 on the left, $1 + 1 = 2$ on the right. O: 6 on the left, $3 + 1 + 2 = 6$ on the right.
- 320 g Fe_2O_3 ; 2 mol Fe_2O_3** $224 + 96 = 320 \text{ g}$. The molar mass of Fe_2O_3 is $2(56) + 3(16) = 160 \text{ g/mol}$, so $320 \text{ g} \div 160 \text{ g/mol} = 2 \text{ mol}$. Oxygen contributes the extra 96 g.

CHALLENGE

$56 + 12 = 68 \text{ g NH}_3$. NH_3 has molar mass 17 g/mol; $68 \text{ g} \div 17 \text{ g/mol} = 4 \text{ mol}$. The reactants are 2 mol N_2 and 6 mol H_2 , twice the equation ratio. Both sides contain 4 mol N atoms and 12 mol H atoms. Atoms are rearranged, so 68 g remains accounted for.

These are idealized paper calculations, not laboratory procedures. Require units and explanations connecting atom counts to mass, not just matching totals. A closed container alone does not guarantee complete reaction; completion and stoichiometric amounts are specified assumptions. Accept equivalent calculations using the supplied rounded values.