Conservation of Mass Lab: Open and closed systems

SNC2D, Unit 3: Chemical Reactions, Lesson 6. 75 minutes. Teacher lesson plan.

Lesson at a glance

In a chemical reaction, the total mass of the products equals the total mass of the reactants, because atoms are only rearranged. If mass seems to change, something entered or left the system, such as a gas.

What students do: Students predict, then measure the mass before and after baking soda reacts with vinegar in an open cup and in a sealed zip-top bag, calculate the change and percent change, account for discrepancies (escaping gas, leaks, buoyancy of the inflated bag, balance precision), and explain the law of conservation of mass with atomic theory.

Curriculum expectations

Code	Students will…
C2.4	use an inquiry process to investigate the law of conservation of mass in a chemical reaction (e.g., compare the values before and after the reaction), and account for any discrepancies [PR, AI]
C3.2	explain, using the law of conservation of mass and atomic theory, the rationale for balancing chemical equations
A1.8	analyse and interpret qualitative and/or quantitative data to determine whether the evidence supports or refutes the initial prediction or hypothesis, identifying possible sources of error, bias, or uncertainty

From The Ontario Curriculum, Grades 9 and 10: Science, 2008 (revised), Science, Grade 10, Academic (SNC2D). A = Scientific Investigation Skills and Career Exploration; B = Biology; C = Chemistry; D = Earth and Space Science; E = Physics. Skill codes: IP = initiating and planning, PR = performing and recording, AI = analysing and interpreting, C = communicating.

Learning goals and success criteria

Learning goals	Success criteria
• We are learning to test the law of conservation of mass. • We are learning to explain differences between expected and measured results.	• I can measure mass before and after a reaction accurately. • I can compare an open system with a closed system. • I can calculate a change in mass and a percent change. • I can account for discrepancies using evidence.

Materials and preparation

- **Slides:** Conservation of Mass Lab deck.
- **Handouts:** Mass Lab (page 1), Analysis (page 2).

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- **Per group:** An electronic balance (0.01 g), two medium zip-top freezer bags, two small plastic cups (that fit inside the bag), baking soda (2.0 g per trial), white vinegar (30 mL per trial), a 50 mL graduated cylinder, a small square of paper, paper towel.
- **Safety:** Goggles on. Use only the amounts listed; a larger amount can burst the bag. Point the bag away from faces while it inflates and open it slowly, away from faces. No tasting. Pour liquids down the sink with water; put bags in the garbage. Wipe spills right away; keep liquids away from the balance.

Lesson sequence

Time (min)	Part	Teacher	Students	Look for
0–10	**Hook**	Where does the mass go?	Predict.	Hypothesis with a reason.
10–20	**Plan**	Open vs closed system.	Read the procedure.	
20–45	**Lab**	Two trials.	Measure and record.	Readings to 0.01 g.
45–60	**Analyse**	Change and percent change.	Calculate.	Correct significant digits.
60–70	**Discrepancies**	Why the bag lost a little.	Explain.	Specific causes.
70–75	**Exit**	Exit ticket.	Answer.	

Differentiation

- **Support:** Calculation frame: before − after = change; change ÷ before × 100% = percent change.
- **ELL:** Labelled diagram of open and closed systems.
- **Challenge:** Use the balanced equation and the masses to estimate how much carbon dioxide should form, and compare it with the open-cup loss.

Assessment

Type	Tool	Purpose
Assessment for learning	Mass Lab and Analysis	Conservation of mass inquiry (C2.4), rationale for balancing (C3.2), analysing data and error (A1.8)

Mass lab: worked answers

- **Open cup change:** 63.96 g − 64.83 g = −0.87 g. Percent change: 0.87 ÷ 64.83 × 100% = 1.3%.
- **Sealed bag change:** 71.38 g − 71.52 g = −0.14 g. Percent change: 0.14 ÷ 71.52 × 100% = 0.20%.
- **Interpretation:** The open cup lost much more mass because carbon dioxide gas escaped into the air. The sealed bag kept almost all the products, so its mass stayed nearly the same: evidence for conservation of mass.

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- **Discrepancy:** The bag still lost 0.14 g: buoyancy of the inflated bag, a tiny leak at the seal, or balance uncertainty (±0.01 g). The change is small compared with the open cup.
- **Copper problem:** 2.54 g of copper heated in air became 3.18 g of copper(II) oxide. Mass increased by 0.64 g because oxygen from the air (outside the system) joined the copper: $2Cu + O_2 \rightarrow 2CuO$.
- **Atomic theory:** Atoms are rearranged, not created or destroyed, so the total mass of the atoms is the same before and after.

Teacher notes

- Safety: Goggles on. Only 2.0 g of baking soda and 30 mL of vinegar per trial; more can burst the bag. Point the inflating bag away from faces and open it slowly. No tasting. Liquids down the sink with water; bags in the garbage. Keep liquids off the balance.
- Closed system set-up: pour 30 mL of vinegar into a small cup and stand it upright inside the bag. Put 2.0 g of baking soda in the bottom corner of the bag, away from the cup. Press out the air, seal, and mass. Then tip the cup inside the sealed bag.
- Why the sealed bag can read slightly lighter: the puffed-up bag pushes aside more air, so the air pushes up on it a little more (buoyancy), and tiny leaks at the seal let some gas out. A capped plastic bottle (with a balloon over the mouth, or the baking soda in a folded tissue dropped in before capping) is a more rigid closed system. Teacher check: with these amounts the bottle builds only gentle pressure.
- Antoine Lavoisier, a French chemist of the late 1700s, is credited with establishing the law of conservation of mass through careful measurements of reactions in sealed containers.
- Sample data (original): open cup 64.83 g → 63.96 g; sealed bag 71.52 g → 71.38 g. Challenge estimate: 2.0 g of baking soda can make at most about 1.0 g of carbon dioxide (1.05 g), so the open-cup loss of 0.87 g makes sense; some gas stays dissolved in the liquid.

Coming up

Lesson 7, Balancing Equations.

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