

Answer Key: Physical vs. Chemical Changes

Course: Integrated Physics and 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. What matters most on this packet is that students **cite the evidence** (a sign of change or a same-substance observation) — not just the P/C label. Notes flag where more than one answer is defensible and list common misconceptions to watch for. Estimated grading time: ~6–8 min per packet.

Start Notice & Wonder grade for effort · ~2 min

1 Notice + wonder: melting ice vs. burning toast.

Full credit for any reasonable notice + wonder. **Ideal:** Notice — "the melted ice can turn back into ice, but burned toast can't turn back into bread." Wonder — "why can one change be undone but not the other?" Accept any on-topic pair. *Science note (not required from students):* melting is a physical change (same substance), while burning is a chemical change (new substances — smoke, gases, char).

2 Which change made a new substance?

Accept any reasoned prior idea. **Target:** the **burning toast** made new substances (black char, smoke, gases); the melted ice is still water. Credit any answer that points to "can't turn it back" or "it looks/smells totally different" as the reason. Do not penalize incomplete prior knowledge — this is a warm-up.

Build Read the Science ~1 min

3 How the particles tell you the type of change.

If the **same particles** appear before and after (only spread apart or rearranged), it is a **physical** change and no new substance forms. If **new particles** appear (the starting particles are rebuilt into different combinations), a **new substance** formed and it is a **chemical** change. Accept equivalent wording that contrasts "same particles" with "new particles."

Apply Use the Data ~3 min

4 Classify and justify (A–F).

A) Ice melting — **P**. Evidence: only a change of state (solid → liquid), no bubbles/color change, and it can be refrozen — **same substance**.

B) Iron rusting — **C**. Evidence: a new flaky orange-brown coating forms with **different properties** (brittle, doesn't shine/conduct) — a new substance.

C) Salt dissolving — **P**. Evidence: liquid stays clear and evaporating leaves the salt **behind unchanged** — same substance, just mixed.

D) Two liquids poured — **C**. Evidence: a **precipitate** (cloudy white solid) forms; also a slight temperature

change — a new solid substance appeared.

E) Candle burning — **C**. Evidence: **light and heat** given off, new odor, and new gases/water vapor produced — new substances form.

F) Paper torn — **P**. Evidence: pieces are smaller but still white paper; nothing bubbles, heats, or changes color — **same substance**, size only.

Scoring: give credit for the correct label **and** a cited observation. A correct label with no evidence earns partial credit.

5 Strongest sign in change D.

The **precipitate** (a new solid forming from two clear liquids) is the **strongest** evidence, because a brand-new substance with a new state clearly appeared — that is hard to explain any other way. The **slight warmth** is **weaker by itself** because temperature can change for physical reasons too (for example, dissolving or simple mixing can warm or cool a liquid without making a new substance). *Defensible alternate:* a student may argue both signs together make the case strongest; accept if they still identify the precipitate as the more decisive single sign.

6 "Disappearing" is not evidence of a new substance.

Something "disappearing" only means it changed state or spread out too finely to see — not that new matter formed. For **ice (A)**, the water is still there as liquid and can be **refrozen**; for **salt (C)**, evaporating the water **leaves the salt behind unchanged**. Both observations show the **same substance** is still present, so both are physical changes. Full credit for citing the "refrozen" and/or "left behind unchanged" observations.

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

a) **O** — recorded directly in Table 1 (cloudy white solid formed).

b) **I** — "a new substance was created" is a conclusion reasoned from the sign, not a recorded observation.

c) **O** — recorded directly (flaky orange-brown layer built up).

d) **I** — "the rust is a different substance" is a reasoned conclusion, not a direct reading.

Observation = recorded/read directly; inference = a conclusion reasoned from evidence.

8 Boiling bubbles vs. candle gas.

Full credit if the student uses "new substance." **Model:** Boiling water's bubbles are water vapor — **still water**, just in the gas state — so no new substance forms and it is a physical change. The candle's gas, light, and odor are **new substances** (gases and smoke) made from the wax reacting with air, so it is a chemical change. The key idea: bubbles alone don't prove a reaction; ask whether the gas is a **new** substance. Accept equivalent wording.

Explain CER (Q9) ~2 min

9 Borderline case — tarnishing silver spoon.

Model answer. Claim: This is a **chemical** change. Evidence: (1) A dark coating with a **different color and dullness** appears on the surface — different properties from the shiny silver. (2) The coating is a distinct layer sitting on top of the metal (shiny metal is still underneath). Reasoning: New properties (color, dullness) mean a **new substance** formed on the surface where silver reacted with something in the air (tarnish). Because a new substance with different properties is present, it is a chemical change, even though only a thin surface layer changed.

Defensible alternate: A thoughtful student may argue it is **borderline / partly physical** because the coating "rubs off" and the silver underneath is unchanged, which sounds reversible. Accept this as a **2-point** answer if it is reasoned — but note the coating itself is a new substance (tarnish), so the best answer is chemical. This ambiguity is the point of the item; reward the quality of the evidence and reasoning, not just the label.

CER scoring rubric (3 points)

Score	Claim	Evidence	Reasoning
3	Clear claim (chemical, or a defensible reasoned borderline call).	Two accurate observations from the description (e.g., different color; different dullness; coating is a distinct layer).	Correctly ties "new/different properties" to a new substance forming.
2	Claim stated, mostly clear.	One solid piece of evidence, or two with a minor error.	Some correct linkage but incomplete or a small misconception.
1	Vague or partly correct claim.	Evidence weak or not from the description.	Little or flawed reasoning; "new substance" idea not used.
0	No/incorrect claim.	No evidence.	No reasoning.

9+ Block addition — conservation of mass.

Full credit for connecting both results to atoms only being **rearranged**. **Model:** In tarnishing, atoms from the air **join** the silver, so the coated spoon gains a little mass. In a burning candle, atoms **leave** as gas, so the leftover candle loses mass. In both, the **total mass of everything** (solid + gases + air involved) is unchanged — no atoms were made or destroyed. You would have to **trap the gases** (a sealed container) to weigh them along with the solid and show the total is constant. Accept equivalent reasoning.

Close ACE ~1 min

ACE Articulate / Connect / Extend.

Articulate: accept any clear statement of the core question — "Did a new substance form?" (If yes → chemical; if no → physical.)

Connect: the clearest chemical rows are **B (rust)**, **D (precipitate)**, or **E (burning)**; the named sign should match (new coating/different properties; precipitate; light/heat/odor/new gas). Accept any of these.

Extend: any correct non-table chemical change with a matching sign — e.g., bread baking (browning + gas), a cut apple browning (color change), fireworks (light), baking soda + vinegar (gas/bubbles), a battery corroding. More than one answer is defensible.

Extend Early finisher & block extension (optional)

EF Build your own sorting table.

Reward a two-column chart with at least four real changes correctly sorted, each with a stated sign or same-substance reason (e.g., chopping = physical/shape only; rusting = chemical/new coating; sugar dissolving = physical/can recover it; wood burning = chemical/light + ash + gas). The circled "least sure" item plus a sentence about why it was tricky earns full credit for reflection.

Block Design an evidence test (sealed bag).

Reward a short numbered plan that: (1) **weighs the sealed bag before** mixing; (2) breaks the tube to mix without opening; (3) **watches for signs** — bubbles/gas, color change, temperature change, a precipitate, light, or odor; (4) **weighs the bag after** to check conservation of mass (mass should be unchanged because the bag is sealed). Best single convincer of a new substance: a change that clearly makes new matter (precipitate or gas) that cannot be undone. Accept any coherent, observation-only procedure.

Watch Common misconceptions

- **"Dissolving and melting are chemical changes."** Both are **physical**. In salt dissolving (C) the salt can be recovered unchanged by evaporation; in melting (A) the water can be refrozen. The substance never changes — only its state or how spread out it is.
- **"Bubbles always mean a chemical change."** Not true. **Boiling water** bubbles are just water vapor (a physical change). Bubbles only signal a reaction when the gas is a **new substance**. Watch for this on Q8 and change E.
- **"A color change always means a chemical change."** Not always. Mixing paints or dyes changes color with **no new substance**. A color change is only strong evidence when it is not simple mixing (e.g., rust in B, or a cut apple browning).
- **"If it disappears, new matter was made / it was destroyed."** (Q6) Disappearing means it changed state or dispersed, not that matter was created or destroyed. Tie this to **conservation of mass**: atoms are only rearranged.
- **Observation vs. inference (Q7).** Students often mark a reasoned conclusion ("a new substance was created," "the rust is different matter") as an "observation." If it states a cause or identity rather than something directly seen/recorded, it is an inference.

Teacher follow-up based on likely errors

If many students mark dissolving or melting (A, C) as chemical, re-anchor to the "can be recovered / refrozen unchanged" observations and to the left panel of Figure 1 (same particles). If students treat every bubble or color change as a reaction, contrast boiling water and paint-mixing with rust and burning, stressing the "new substance" test. If the CER (Q9) label is treated as the whole answer, remind them the points are for **evidence + reasoning**. The "bubbles = chemical" and "color change = chemical" misconceptions are the highest-value items to address next class.

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