

Substitute Guide: Physical vs. Chemical Changes

Course: Integrated Physics and Chemistry (Grades 9–12) **Subject:** Science **Time:** ~50 min standard · ~90 min block Science

Learning goal (plain language)

Students learn to tell a **physical change** (a change in state, shape, or size with **no new substance** — like melting or dissolving) from a **chemical change** (a reaction that forms **one or more new substances** — like burning or rusting), and to use the **signs of a reaction** — gas/bubbles, color change, temperature change, a precipitate, or light — as **evidence**. Working alone with a pencil, students read a short passage, study a particle-model diagram, analyze a table of described changes and their observations, classify and justify each, and write an evidence-based explanation (CER). **You do not need a science background to run this.** Everything students need is printed in their packet. This is a **paper** activity — no lab, no materials, no hazards; nothing is mixed, heated, or measured.

Standards alignment

Framework: 19 TAC Chapter 112 (Integrated Physics and Chemistry). Knowledge & skills on **changes in matter and evidence of chemical reactions**.

- **Provisional — physical vs. chemical change:** distinguish physical changes (state, shape, size; no new substance) from chemical changes in which one or more new substances form.
- **Provisional — evidence of a reaction:** recognize signs that a chemical reaction has occurred, such as gas production, color change, temperature change, precipitate formation, or emission of light.

Provisional — pending educator verification against the current official TAC source. No section number or code letters are asserted here; they are to be confirmed.

(Standards are paraphrased here, not quoted. Please confirm the section and wording against your official source. This packet does not claim formal alignment to the TEKS.)

Setup Before class (5 min)

- Count and hand out one **student packet** per student.
- Confirm each student has a **pencil**. No calculators, computers, or lab items are needed — there is no math and nothing to mix or measure.
- Write the date on the board and remind students to fill in the name line.
- Keep the **answer key** with you — it is a separate file and is **not** in the student packet.

Materials What's needed

- Printed student packet (4–6 pages) per student.
- Pencil per student.
- This guide and the separate answer key (teacher only).
- No technology, no calculator, no lab equipment, no chemicals, no safety hazards.

Timing Suggested pacing — standard vs. block

Segment	Standard (~50 min)	Block (~90 min)	What students do
Start — Notice & Wonder	5 min	5 min	Q1–Q2 warm-up
Build — Read the science	8–12 min	12 min	Read passage, word bank, particle-model diagram; Q3
Apply — Use the data	20–25 min	25 min	Table 1; Q4–Q8 (classify & justify, strongest sign, trap check, observation vs. inference, look-alikes)
Explain — CER	7–10 min	10 min	Q9 borderline case (claim/evidence/reasoning); block adds the conservation-of-mass paragraph
Close — ACE	5 min	5 min	Articulate / Connect / Extend
Continue — early finishers	optional	+30 min	Build a sorting table; block adds the sealed-bag evidence-test plan

On a **standard ~50-minute** period, the core stops after the CER (Q9) and ACE; the early-finisher sorting table is optional. On a **~90-minute block**, everyone also writes the **conservation-of-mass** addition to Q9 (why a tarnishing spoon gains mass while a burning candle loses it, yet both obey conservation of mass) and completes the sealed-bag evidence-test plan.

Script Read aloud to start

"Today's assignment is a paper science investigation called *Physical vs. Chemical Changes*. You will work by yourself with just a pencil — no computers or calculators, and nothing to build, mix, or measure. First read the short passage and study the diagram that shows tiny particles before and after a change. Then look at the table: it describes six changes and gives you the observations someone already recorded, so you don't have to do any experiments. Your job is to decide whether each one is a **physical** change (same substance — just melting, dissolving, or changing shape) or a **chemical** change (a new substance forms, like rusting or burning), and to point to the **evidence** that tells you. Answer the questions in order; if one is tricky, skip it and come back. Write in complete sentences where it asks you to explain. You may quietly read the passage aloud to yourself. Put your name, class period, and date at the top now. You have about 50 minutes (or the full block); raise your hand if you need help understanding a word."

Support When students ask for help

- **You may read any part aloud** to a student or the class.
- If they are unsure "physical or chemical," point them to the one key question: "**Did a new substance form?**" — and to **Figure 1** (same particles vs. new particles).
- Remind them a single sign is a **clue, not proof**: boiling bubbles and paint-mixing color changes are physical. The reference box lists this.
- Encourage the printed **sentence stems** for the CER (Q9) and ACE sections.
- Do **not** give answers; prompt with "What did the observation say?" or "Could you get the original substance back?"
- It is fine if a student cannot finish the optional early-finisher or block task.

Access Accommodations & language support

- **Read-aloud** of any passage or question is allowed for all students.
- Point students to the **sentence stems** and the **Word Bank** (definitions provided).

- Extended time is fine; the core can stop after Q9 if time runs short.
- Students may answer in phrases if writing full sentences is a barrier, as long as they name the evidence.
- The packet is grayscale-safe — it prints and reads clearly in black and white; the particle diagram uses patterns (dots, hatching, solid) and labels, not color.

Tools Allowed & not allowed

Allowed: pencil, the printed packet, quiet self-read-aloud. **Not needed / not allowed:** calculator (there is no math), phones, computers, lab materials or chemicals.

Collect at the end: Collect every packet, whether finished or not, with names on them. Stack them for the teacher. Note on a sticky how far most students got and any questions that caused confusion.

Answer key: The **answer key is a separate file** (answerkey.html) and is for the teacher only. Please do not hand it to students.

Teacher follow-up (for the returning teacher)

Watch for the two highest-value misconceptions: students thinking *dissolving or melting is chemical*, and thinking *any bubbles or any color change means a chemical reaction*. A quick next-day discussion contrasting boiling water and paint-mixing (physical) with rust and burning (chemical), and returning to the particle model (same particles vs. new particles), would reinforce this well. The classify-and-justify item (Q4) and the CER (Q9) responses show who can cite **evidence** rather than just guess a label; the observation- vs-inference item (Q7) shows who can separate what was recorded from what was concluded.

HS_IPC_PhysChemChange_01 — Physical vs. Chemical Changes Substitute Guide

Physical vs. Chemical Changes

Course: Integrated Physics and Chemistry (Grades 9–12) **Subject:** Science **Time:** ~50 min standard · ~90 min block **Work mode:** Independent · pencil only Science

Start Here

This is a **paper investigation**. You will study a particle-model diagram, read a short passage, and analyze a table of described changes and their observations using a pencil. You do **not** need a computer, a lab, or any materials besides this packet and a pencil. There are **no hazards** — nothing is mixed, heated, or measured; every observation you need is already printed for you. Work by yourself and do your best thinking. Write in complete sentences where you are asked to explain, and always point to the **evidence** that supports your answer. If a question is hard, skip it, keep going, and come back. Reading the passage quietly aloud to yourself is allowed and encouraged.

Start Notice & Wonder 5 min

Think about two everyday events: an ice cube melting in a glass, and a piece of toast burning until it is black and smoking.

1An ice cube melts into liquid water; a slice of bread burns into black, smoking char. Both are called "changes," but they feel different. Write **one thing you notice** and **one thing you wonder** about how these two changes are different.

2In which of those two changes do you think a **brand-new substance** was made — something that was not there before? Give your best first idea and say what makes you think so.

Build Read the Science 8–12 min

Physical changes, chemical changes, and the signs of a reaction

Matter can change in two very different ways. The key question is always the same: **Was a new substance made?**

- **Physical change** — the substance changes its **state, shape, or size**, but it is still the **same substance**. No new material forms. The same particles are just rearranged or moved farther apart. Examples: melting, freezing, boiling, dissolving, crushing, bending, or cutting. A physical change can usually be **reversed** (liquid water can be frozen back into ice).
- **Chemical change (chemical reaction)** — the starting substances are changed into **one or more new substances** with new properties. The particles are taken apart and rebuilt into different combinations. Examples: burning, rusting, digesting food, and many mixtures that react. A chemical change is usually **hard to reverse**.

Signs that a chemical reaction may have occurred. You cannot see the particles, so scientists look for observable **evidence**. Watch for:

- **Gas / bubbles** forming when nothing was boiling.
- **Color change** that is not simply mixing two colors.

- **Temperature change** — the material gets hotter or colder on its own (energy is released or absorbed).
- **Precipitate** — a solid that suddenly appears when two clear liquids are combined.
- **Light** or **odor** given off (for example, a flame or a new smell).

Important cautions. A single sign is a *clue*, not proof. Some physical changes *look* like reactions: boiling water makes bubbles (just water vapor, not a new substance); dissolving salt can cool the water; mixing paint changes color without making anything new. The strongest case for a chemical change is when a sign appears **and** you can tell a **new substance with new properties** is present and the change is hard to undo.

Conservation of mass. In *either* kind of change, atoms are never created or destroyed — they are only rearranged. So the **total mass stays the same**. If gas escapes into the air, the leftover solid weighs less, but the mass of the solid *plus* the escaped gas still equals the starting mass.

Word Bank

physical change

a change in state, shape, or size with **no new substance** formed (e.g., melting, dissolving).

chemical change

a change that forms **one or more new substances** (also called a chemical reaction; e.g., burning, rusting).

substance

a single kind of matter with its own fixed properties (color, density, boiling point, etc.).

precipitate

a solid that forms and settles out when two liquids are combined.

evidence

an observation you can point to that supports a claim (a sign of change).

conservation of mass

the rule that total mass stays the same because atoms are only rearranged, never made or destroyed.

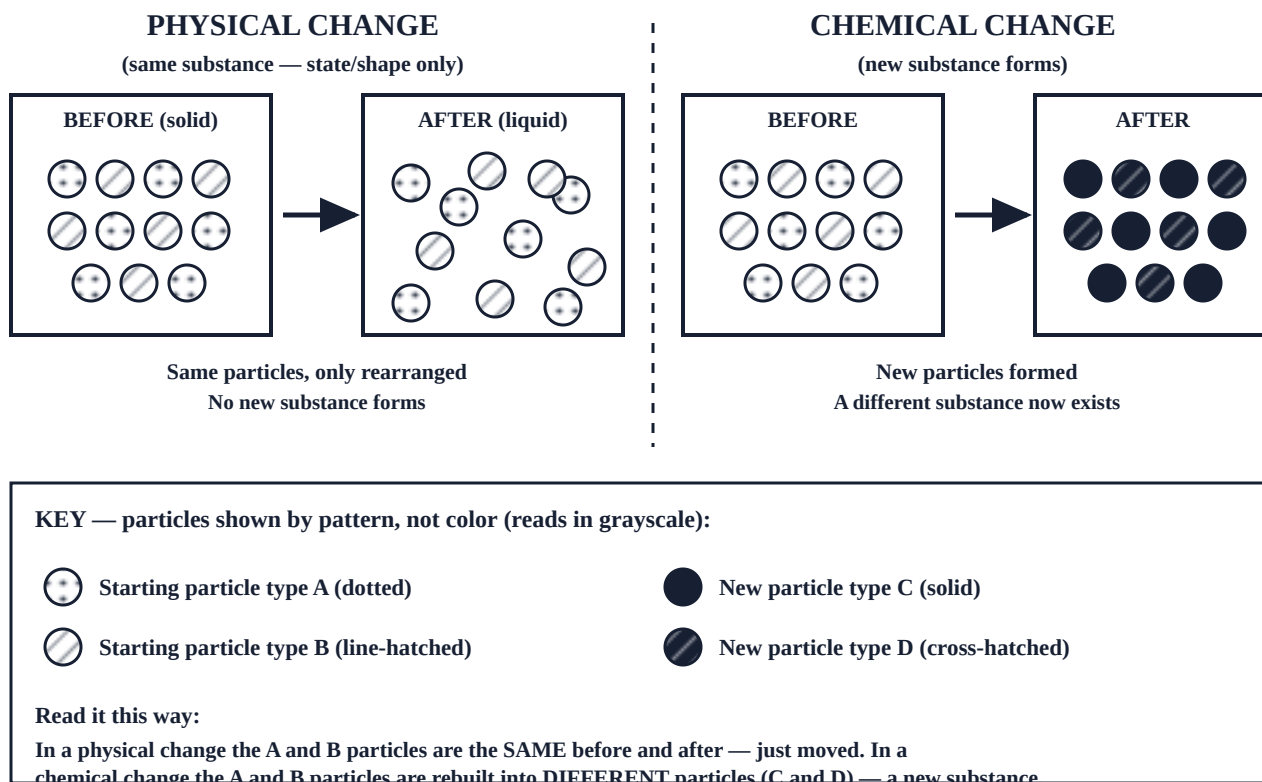


Figure 1. A particle model of the difference between the two changes. On the **left**, a **physical change**: the same particles (dotted type A, line-hatched type B) appear before and after — they are only spread farther apart, so **no new substance** forms. On the **right**, a **chemical change**: the starting

particles are rebuilt into **new particles** (solid type C, cross-hatched type D), so a **new substance** now exists. Meaning is carried by **patterns and labels**, not color, so the figure reads clearly in grayscale.

3Using Figure 1, describe in one sentence how you can **tell from the particles** whether a change is physical or chemical. Use the words **same particles** and **new particles**.

Apply Use the Data 20–25 min

Table 1 describes six changes and the observations someone recorded for each. You will not perform these — the observations are given. Study the table, then answer. (These are original descriptions written for this packet.)

Table 1. Six described changes and the observations recorded for each (original scenarios).

#	Change described	Observations recorded
A	An ice cube is left on a warm counter.	The solid turns to liquid water; no bubbles, no color change; it can be refrozen into ice.
B	A strip of shiny iron sits outdoors for two weeks.	A flaky orange-brown layer builds up; the new coating is brittle and does not conduct or shine like the iron did.
C	A spoon of table salt is stirred into a glass of water.	The salt seems to disappear; the liquid stays clear; evaporating the water leaves the salt behind unchanged.
D	Two clear liquids are poured together.	Instantly a cloudy white solid forms and settles to the bottom; the mixture also feels slightly warm.
E	A birthday candle burns.	The flame gives off light and heat; wax disappears; a faint smoky odor and a little water vapor and gas are produced.
F	A sheet of paper is folded and torn into small pieces.	The pieces are smaller but still white paper; nothing bubbles, heats, or changes color.

4**Classify and justify.** For each change A–F, write **P** (physical) or **C** (chemical), then in a few words **justify** your answer by naming the **evidence** from Table 1 you used.

- A) Ice melting _____ Evidence: _____
B) Iron rusting _____ Evidence: _____
C) Salt dissolving _____ Evidence: _____
D) Two liquids poured _____ Evidence: _____
E) Candle burning _____ Evidence: _____
F) Paper torn _____ Evidence: _____

5**Strongest sign.** Look again at change **D** (two clear liquids form a cloudy solid). Two signs were recorded: a **precipitate formed** and the mixture **felt slightly warm**. Which single sign is the **strongest evidence** that a chemical reaction occurred, and why is the other sign by itself weaker?

6**Trap check.** A classmate says, "Change A (ice melting) and change C (salt dissolving) must be chemical because the ice disappears and the salt disappears — the stuff is gone!" Explain why **disappearing is not evidence of a new substance** here. Point to the observation in Table 1 that shows the substance is still the same.

7**Observation vs. inference.** Write **O** if the statement is an observation (something recorded directly in Table 1) or **I** if it is an inference (a conclusion you reason out).

- _____ a) In change D, a cloudy white solid formed and settled to the bottom.
_____ b) A new substance was created when the two liquids in change D were combined.
_____ c) In change B, a flaky orange-brown layer built up on the iron.

____ d) The rust in change B is a different substance than the iron it formed on.

8Two look-alikes. Boiling water makes bubbles, and burning a candle makes bubbling gas too. Using the idea of a **new substance**, explain why the bubbles from **boiling water** are a **physical** change but the gas and light from a **burning candle** are a **chemical** change.

Explain Claim–Evidence–Reasoning 7–10 min

Question 9. Here is a **borderline case**. A shiny silver spoon is left in a dish for a month and slowly turns dull and dark on the surface; the dark coating can be gently rubbed off, revealing shiny metal underneath, and the coating has a different color and dullness than the silver. Is this a **physical** or a **chemical** change? Write a **claim**, support it with **two pieces of evidence** from the description, then explain your **reasoning** using the idea of a new substance and its properties.

Sentence stems you may use: "This is a ____ change because..." · "One piece of evidence is..." · "A second piece of evidence is..." · "This shows a new substance formed because its properties (color / dullness) are different from..."

Claim

Evidence (two pieces from the description)

Reasoning

Block-period addition — conservation of mass:

Extend your reasoning above. When the silver tarnishes, atoms from the air combine with the silver surface, so the dark coating actually has **slightly more mass** than the clean silver did. When a candle (change E) burns, the leftover candle weighs **less** because gas escapes into the air. On the lines below, explain how **both** results still obey **conservation of mass** — that atoms are only rearranged, never created or destroyed — and why you would have to **trap the gases** to show the total mass did not change.

Close ACE Wrap-Up 5 min

Articulate

In your own words, explain the one question you ask to tell a physical change from a chemical change.

Connect

Point to one row of Table 1 whose observations give the clearest evidence of a **chemical** change. Name the sign.

Extend

Give a **new** everyday example (not in Table 1) of a chemical change, and name the sign of a reaction you would expect to see.

Continue Early Finisher & Block Extension optional · block ~+30 min

If you finish early (no new materials needed):

Build your own sorting table. On the back of this page, make a two-column chart headed "Physical" and "Chemical." List at least **four changes from your own life** (for example: chopping vegetables, a nail rusting, sugar dissolving in tea, wood burning in a campfire). For each one, write the **sign** or reasoning that put it in that column. Circle the one change you were least sure about and write one sentence explaining why it was tricky.

Block-period extension — design an evidence test:

Imagine you are handed a sealed clear bag containing a mystery solid and a small tube of liquid that you can break to mix them, **without opening the bag**. Describe a plan, using only observation, to decide whether mixing them causes a **chemical** change. List the **signs** you would watch for, explain how the sealed bag lets you check

conservation of mass (weigh the bag before and after), and state which single observation would most convince you a **new substance** formed. Write it as a short numbered procedure.

Turn in: Hand in this whole packet with your name, class period, and date filled in. Make sure questions 1–9 and the ACE box are answered. The block conservation-of-mass paragraph, the early-finisher sorting table, and the block evidence-test plan are optional — turn them in too if you did them.

HS_IPC_PhysChemChange_01 — Physical vs. Chemical Changes Student Packet



TEACHER ANSWER KEY FOLLOWS

Do not copy the pages after this divider for students.

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.

HS_IPC_PhysChemChange_01 — Physical vs. Chemical Changes Teacher Answer Key