

Grade 4 Chemistry Quiz – Acids and Bases

Duration: 45 minutes · Total: 75 marks

Instructions:

- Read each question carefully. Show all reasoning steps and label each inference as Premise, Inference, or Conclusion where asked.
- For any claim you make, include an evidence log entry listing the source of the data or observation (e.g., classroom observation, provided table, known property).
- Write answers in the spaces provided on your printed copy. If extra space is needed, attach additional sheets and label them with the question number.
- No calculators or external devices. Use only knowledge from class and the data provided in the questions.

Success criteria (what you must show)

- Use core axioms (basic definitions) of acids and bases to justify conclusions.
- Provide step-by-step logical reasoning for each inference.
- Map claims to evidence (claim -> warrant -> backing).
- Identify assumptions and test counterexamples.
- Produce safe, bias-aware recommendations in real-world contexts.

DOK targets (indicator of cognitive demand)

- Most items target DOK 2–3 (skill/concept reasoning and strategic thinking). Items 6, 12, 14, and 15 target DOK 3 (multi-step reasoning and synthesis).

Questions (exactly 15)

1. (3 marks) Core axioms: State two core axioms (short, one-line each) that scientists use to define acids and bases in water. For each axiom give one simple classroom example substance and one single-step inference (label Premise and Inference) that follows from the axiom.
2. (6 marks) Observation table (use logic to classify). You are given four unknown liquids A–D with these observations:
 - A turns blue litmus red; reacts with a small piece of zinc metal producing bubbles.
 - B turns red litmus blue; feels slippery when a tiny touch test is done.
 - C does not change either litmus; no reaction with zinc.
 - D turns blue litmus red; no reaction with zinc; smells sour.For each liquid, state whether it is Acid, Base, or Neutral. For each decision write: (a) Premise(s) (which observation(s) you used), (b) Inference (why that observation means

acid/base/neutral), and (c) Conclusion. Each explanation must be 1–2 sentences. (1.5 marks each)

- (5 marks) Analyze assumptions: A student claims: "If a liquid turns blue litmus red, then it is dangerous to touch." List two assumptions in that claim. For each assumption, give one counterexample (real or hypothetical) that shows the assumption may be false. Conclude whether the original claim is valid and explain using logical statements.
- (6 marks) Evidence log and mapping. Use the pH data below (measured once with a pH meter) to answer the prompts.

Measured pH of five solutions:

- Solution W: pH 2.0
- Solution X: pH 7.0
- Solution Y: pH 9.0
- Solution Z: pH 5.5
- Solution Q: pH 11.5

(a) For each solution label Acid, Base, or Neutral. (2 marks)

(b) Create one evidence-log entry (format: Claim -> Data used -> Source/measurement -> Reasoning) supporting why Solution Q is a base. (2 marks)

(c) Map one claim (from any solution) with claim -> warrant -> backing (one line each). (2 marks)

- (4 marks) Critique flawed reasoning. Read this student statement: "Vinegar is a base because it dissolves some metals, so it must be chemically similar to baking soda." Identify two specific logical flaws in that statement and write a corrected version (one sentence) that is logically valid and based on core axioms.
- (6 marks) Derive neutralization using tokens. Start from the core axiom: "Acids release H^+ ions in water. Bases release OH^- ions in water." Use a token model: represent each H^+ as a red token and each OH^- as a blue token. If you mix 3 red tokens and 2 blue tokens, show step-by-step token cancellation and state the final ion balance and whether the mixture will be acidic, basic, or neutral. Include a one-line explanation of why the token result connects to pH direction. (Show Premise -> Inference -> Conclusion.)
- (4 marks) Bias audit of sampling. A class tested only liquids found in the kitchen (vinegar, lemon juice, baking soda solution, soap water) to learn about acids and bases. List two ways this sampling could bias their conclusions about acids and bases in general environments (e.g., rivers, cleaning products in stores). For each bias give one consequence for decision-making (safety or storage).
- (5 marks) Evidence mapping. The claim: "Baking soda cleans because it is a base." Organize this claim into three parts: Claim -> Warrant (explain mechanism in one sentence) -> Backing

(give one piece of evidence or observation that supports the warrant). Then note one limitation of the backing.

9. (3 marks) Reflection on criteria and DOK. Choose any one earlier question you answered. Write two short sentences: (a) which success criterion from the top of the exam the answer satisfied, and (b) which DOK level it targeted and why (one short reason).
10. (4 marks) Proof-style: Given models showing water molecules producing equal numbers of H^+ and OH^- ions (showing 1 red, 1 blue token), show in logical steps why pure water is neutral. Label steps as Premise 1, Premise 2, Inference, Conclusion.
11. (3 marks) Safety rules: List three clear, age-appropriate safety rules for handling acids and bases in a classroom. For each rule provide one short justification tied to a property of acids or bases.
12. (8 marks) Design an indicator test (multi-step real-world application). Describe a short classroom test using red cabbage juice as a pH indicator to determine whether three unknown liquids are acidic, basic, or neutral. Include: (a) a numbered procedure with control(s) (3 marks), (b) predicted color results for acid/base/neutral and why (2 marks), (c) one evidence-log entry example recording an observed color for Unknown 1 and the conclusion you draw (2 marks), and (d) one safety step and its justification (1 mark).
13. (3 marks) Counterexample test: The statement: "All bases feel soapy." Provide one real or realistic counterexample (name a base that does not feel soapy) and explain in one sentence why the general statement is false.
14. (6 marks) Comparative critique and defense. Two students argue about rainwater:
 - Student A: "Rainwater with pH 5 is normal and safe for plants."
 - Student B: "Rainwater with pH 5 is acid rain and harmful to plants."Using the evidence: typical unpolluted rain has pH around 5.6; acid rain is often defined as pH below 5.0 and can harm sensitive lakes/plants. Write a short critique of each student's reasoning (2 marks each) and a defended conclusion (2 marks) that uses the given evidence and states any assumptions you make.
15. (11 marks) Open-response synthesis and recommendation. A school stores several cleaning agents: an acidic bathroom cleaner (pH 1.5), a vinegar-based cleaner (pH 2.8), an all-purpose base cleaner (pH 11.0), and a mild soap solution (pH 9.0). Using evidence from core axioms, safety rules, bias awareness, and token neutralization ideas:
 - (a) Recommend a storage and labeling plan (3 marks) that reduces risk of accidental mixing and exposure. Include location, labeling language, and one physical separation strategy.
 - (b) Provide one tested rule (policy) for student access to these materials (2 marks).
 - (c) Explain how your plan addresses at least two biases or data limitations that could arise

from the school's previous storage practice (2 marks).

- (d) Provide an evidence-log (at least two entries) that justify your plan (3 marks). Each entry must show Claim -> Data/measure -> Source/observation -> Reasoning.
-

Answer Key and Marking Guide (detailed explanations and scoring)

Notes for scorers: award partial credit for correct reasoning steps even if final label is mistaken, as long as logical chain is coherent. Look for explicit Premise/Inference/Conclusion labeling where requested.

1. (3 marks)

- Expected answers:
 - Axiom 1 (Acid): "An acid is a substance that releases H^+ (hydrogen) ions when dissolved in water." Example: vinegar (acetic acid). Premise: vinegar in water releases H^+ ; Inference: presence of extra H^+ makes solution acidic -> Conclusion: vinegar is an acid.
 - Axiom 2 (Base): "A base is a substance that releases OH^- (hydroxide) ions when dissolved in water." Example: baking soda solution (sodium bicarbonate in water yields OH^- relative effect). Premise: baking soda in water increases OH^- /reduces H^+ ; Inference: presence of OH^- makes solution basic -> Conclusion: baking soda solution is a base.
- Marking: 1 mark per correctly stated axiom (1 each = 2), 1 mark for at least one correct example and a labeled inference (1).

2. (6 marks; 1.5 each)

- Expected classifications and reasoning:
 - A: Acid. Premise: turns blue litmus red & reacts with zinc (acid reacts with some metals -> H_2 gas). Inference: turning blue litmus red indicates H^+ present; metal reaction consistent with acid -> Conclusion: A is acid.
 - B: Base. Premise: turns red litmus blue & feels slippery. Inference: red->blue indicates OH^- ; slippery feel is characteristic of bases -> Conclusion: B is base.
 - C: Neutral. Premise: no litmus change & no zinc reaction. Inference: no H^+ or OH^- indicators present -> Conclusion: neutral (e.g., water).
 - D: Acid. Premise: turns blue litmus red & smells sour. Inference: blue->red indicates acid; sour smell supports acid (like vinegar) -> Conclusion: acid.
- Marking: 0.75 marks for correct label and 0.75 for a correct Premise/Inference/Conclusion chain.

3. (5 marks)

- Sample answer:
 - Assumption 1: "Turning blue litmus red implies danger." Counterexample: Lemon juice turns blue litmus red but is safe to touch in small amounts. (1.5 marks: identify assumption 0.5, counterexample 1.0)

- Assumption 2: "All acids are dangerous to touch." Counterexample: Dilute orange juice is acidic but not dangerous. (1.5 marks)
- Conclusion: The claim is not valid as a general rule; whether a substance is dangerous depends on concentration and properties (0.5–1 mark). Scoring: 2 assumptions with counterexamples = 3 marks, conclusion = 2 marks.

4. (6 marks)

- (a) Labels:
 - W pH 2.0 -> Acid
 - X pH 7.0 -> Neutral
 - Y pH 9.0 -> Base
 - Z pH 5.5 -> Acid (mild)
 - Q pH 11.5 -> Base (stronger)
(2 marks: 0.4 each)
- (b) Evidence-log entry example:
 - Claim: Solution Q is a base. Data used: measured pH 11.5. Source: pH meter reading (class measurement). Reasoning: $\text{pH} > 7$ indicates $[\text{OH}^-] > [\text{H}^+]$, consistent with core axiom that bases produce OH^- . (2 marks)
- (c) Mapping claim -> warrant -> backing example:
 - Claim: Solution Z is acidic. Warrant: $\text{pH} < 7$ indicates more H^+ ions than OH^- . Backing: measured pH 5.5 (pH meter reading). (2 marks)

5. (4 marks)

- Flaws identified (examples):
 - Flaw 1: Dissolving metal is not exclusive to bases; some acids react with metals. (1 mark)
 - Flaw 2: Similar reactions do not prove chemical similarity; need to test ion production (H^+ vs OH^-) or pH. (1 mark)
- Corrected valid sentence:
 - "Vinegar is an acid because it produces H^+ ions in water (and has measured pH below 7), while baking soda is a base because it produces OH^- /reduces H^+ ; dissolving metal alone is not sufficient evidence." (2 marks for corrected statement citing core axiom)

6. (6 marks)

- Student model:
 - Premise: Acid releases H^+ (red tokens), base releases OH^- (blue tokens). Start: 3 red tokens + 2 blue tokens.
 - Step 1 (Inference): Each red + blue pair cancels to form neutral water ($H^+ + OH^- \rightarrow H_2O$). Cancel 2 pairs \rightarrow removes 2 red and 2 blue.
 - Remaining: 1 red token left, 0 blue tokens left.
 - Conclusion: Ion balance is 1 H^+ in excess \rightarrow mixture is acidic. pH will be lower than 7 (more H^+). (Marks: 1 for correct token cancellation steps, 1 for correct final count, 1 for correct acidity conclusion + link to pH; breakdown across clarity = 6 total)

7. (4 marks)

- Bias 1: Kitchen sampling excludes industrial and environmental acids/bases (e.g., battery acid, river runoff). Consequence: underestimating hazards and improper storage. (2 marks: 1 for bias, 1 for consequence)
- Bias 2: Kitchen items are mostly dilute, so they under-represent concentration extremes. Consequence: students may assume all acids/bases are safe to touch. (2 marks)

8. (5 marks)

- Claim \rightarrow Warrant \rightarrow Backing:
 - Claim: Baking soda cleans because it is a base.
 - Warrant: As a base, baking soda ($NaHCO_3$) can neutralize acidic stains and react with grease/organic acids, helping lift dirt.
 - Backing: Observations: baking soda paste removes vinegar stains and deodorizes surfaces in demonstrations. (3 marks total for correct mapping)
- Limitation: Baking soda does not remove all types of stains (e.g., strongly oxidized stains); cleaning depends on physical abrasion and other chemicals as well (2 marks split).

9. (3 marks)

- Sample acceptable reflection:
 - (a) "I satisfied the criterion: mapped claims to evidence (Claim \rightarrow Warrant \rightarrow Backing) by listing data and measurement." (1.5 marks)
 - (b) "DOK 2–3: It targeted DOK 2 because I explained reasoning that required connecting evidence to claims." (1.5 marks)
- Marking: 1.5 each for clear matching reflection and correct DOK justification.

10. (4 marks)

- Proof steps:
 - Premise 1: Water molecules produce equal H^+ and OH^- spontaneously at neutral conditions (model shows 1 red, 1 blue).
 - Premise 2: Acidity/basicity depends on which ion is in excess (core axiom).
 - Inference: With equal numbers, neither H^+ nor OH^- is in excess.
 - Conclusion: Pure water is neutral (pH ~ 7). (Marking: 1 each for premises, inference, conclusion; 4 marks)

11. (3 marks)

- Three safety rules (each 1 mark with justification):
 - Rule 1: Always wear safety goggles when handling strong acids or bases – justification: they can splash and damage eyes (acid burns/alkali burns).
 - Rule 2: If you spill a strong acid/base, tell the teacher and follow neutralization/cleanup instructions – justification: concentrated solutions can burn skin and damage surfaces.
 - Rule 3: Do not mix cleaners unless instructed – justification: mixing can produce dangerous reactions or gases.

12. (8 marks)

- (a) Procedure with controls (3 marks):
 1. Prepare red cabbage juice indicator and pour equal small drops into three labeled test wells (Unknown 1–3) and a control well with plain water. (1 mark)
 2. Add one drop of each unknown to its well; observe and record color changes after 30 seconds. (1 mark)
 3. Compare colors to the control and to known acid (vinegar) and base (baking soda solution) reference wells. (1 mark)
- (b) Predicted color results and why (2 marks):
 - Acid \rightarrow pink/red (because indicator turns red where H^+ is higher).
 - Neutral \rightarrow purple.
 - Base \rightarrow green/blue (indicator shifts toward blue/green in presence of OH^-).
- (c) Evidence-log example (2 marks):
 - Claim: Unknown 1 is a base. Data: Unknown 1 changed indicator to green. Source: observation at 10:12 AM during test. Reasoning: cabbage indicator turns green/blue in presence of OH^- , so Unknown 1 has $OH^- \rightarrow$ base.

- (d) One safety step (1 mark):
 - Wear gloves and goggles; justification: indicator and unknowns may splash and some unknowns could be corrosive.

13. (3 marks)

- Counterexample:
 - Sodium carbonate (washing soda) is a base but can feel grainy rather than soapy; some strong bases (e.g., ammonia solutions) may not feel soapy. Explanation: "Soapy" feel depends on specific substances and their reaction with skin oils, not all bases. (1 mark for counterexample name, 2 marks for explanation)

14. (6 marks)

- Critique Student A (2 marks):
 - A's reasoning: "pH 5 is normal and safe" – critique: uses an absolute statement ignoring that rain pH can vary and some ecosystems are sensitive; pH 5 is lower than neutral and close to acid-rain definitions; needs context. (1–2 marks for noting missing context and assumptions)
- Critique Student B (2 marks):
 - B's reasoning: "pH 5 is acid rain and harmful" – critique: statement is too general; acid rain is often defined below pH 5.0; pH 5 alone does not guarantee harmful effects without considering duration and sensitivity of environment. (1–2 marks)
- Defended conclusion (2 marks):
 - Balanced conclusion: "Given evidence, pH 5 is lower than typical unpolluted rain (5.6) and is close to thresholds for acid rain; we should monitor changes and consider local sensitivity— pH 5 may be concerning for sensitive lakes/plants but is not automatically harmful in all contexts." State assumption: using provided definitions and assuming single pH reading representative. (2 marks)

15. (11 marks)

- Model answer should include clear, safety-focused, bias-aware plan with evidence logs. Suggested points and marking:
 - (a) Storage and labeling plan (3 marks):
 - Keep strong acidic bathroom cleaner (pH 1.5) in a locked cabinet clearly labeled "Strong Acid – Keep Out of Reach of Students" with hazard pictogram and concentration. Place acid cabinet separate from base storage (separate locked cabinet across room). Physical

separation strategy: store acids and bases in different labeled, spill-resistant bins with secondary containment (1 mark for location, 1 mark for label language/pictogram, 1 mark for physical separation).

- (b) Student access policy (2 marks):
 - Rule: Students may not access concentrated cleaning agents; only trained staff may handle them using PPE. Documentation: require sign-out log for use. (1 mark for rule, 1 mark for enforcement mechanism)
- (c) Address biases/data limitations (2 marks):
 - Bias 1: Previous storage may have assumed all cleaners are safe like kitchen items (dilute). Correction: plan separates strong agents and uses concentration-based labeling. (1 mark)
 - Bias 2: Sampling bias – previous practice may not have tested long-term exposure risks; correction: include periodic inspection and monitoring (1 mark)
- (d) Evidence-log (3 marks – 1.5 marks each min. for clarity):
 - Entry 1:
 - Claim: Strong acid cleaner should be locked away. Data/measure: product labeled pH 1.5 and corrosive hazard statement on bottle. Source/observation: product label and MSDS (teacher checked). Reasoning: pH 1.5 indicates high $[H^+]$, risk of burns; locking reduces accidental exposure.
 - Entry 2:
 - Claim: Acids and bases must be stored separately. Data/measure: core axiom $H^+ + OH^- \rightarrow H_2O$ (neutralization) and incident reports where mixing caused neutralization or dangerous splashes (class records/hypothetical). Source: classroom safety records/reference chemistry principle. Reasoning: separating reduces accidental mixing and harmful reactions.
- Marking: award according to presence of all components, clarity of link to axioms, and bias/safety reasoning.

End of answer key.