Zoe and the Secret Lair of Matter

Grade 5 science superheroes

Students will identify and compare physical and chemical properties of matter, including mass, volume, density, solubility, and state of matter, using evidence from observations.

Name: _____ Date: _____

1. Zoe enters the secret lair and spots two power crystals on a table. One crystal is hard and clear. The other is soft and cloudy. Hardness and color are physical properties of matter. True or False: Hardness and color describe what a material IS MADE OF.

2. Zoe picks up her hero badge. The badge is a solid. Which best describes a solid? A) It has a definite shape and definite volume. B) It has no definite shape but definite volume. C) It has no definite shape and no definite volume.

3. Zoe finds a villain trap filled with a mystery liquid. She notices the liquid takes the shape of its container but keeps the same volume. She also sees it does NOT dissolve the metal walls. Name TWO physical properties Zoe just observed about this liquid.

4. Zoe places a power crystal in water. The crystal sinks straight to the bottom. Zoe knows water has a density of 1 g/cm³. What does the crystal sinking tell Zoe about the crystal's density compared to water's density? Explain using the word DENSITY.

5. Inside the secret lair, Zoe compares two substances. Substance A dissolves completely in water. Substance B does not dissolve at all. Zoe heats both substances. Substance A boils at 100°C. Substance B melts at 1,538°C. Use TWO properties to explain which substance is most likely iron.

6. Zoe is trapped inside the villain's lair. The only exit is sealed with a lock made of a white powder. Zoe has two options: powder X (salt, soluble in water) or powder Y (sand, insoluble in water). She has a bottle of water. Zoe needs to dissolve the powder to unlock the door. Which powder should Zoe choose, and why is solubility a physical property and NOT a chemical property?

7. Zoe discovers a glowing gas leaking from a pipe in the secret lair. The gas has no color, no odor, and a very low density. When Zoe holds a flame near the gas, it burns and produces water vapor — a new substance forms. Identify one physical property AND one chemical property of this gas. Explain how you know which is which.

8. Zoe has defeated the villain and holds the final power crystal — her mission is complete. She writes her lab report. The crystal is purple, hard, does not dissolve in water, has a density of 3.5 g/cm³, and does NOT burn. Another hero claims the crystal changed into a new substance when it was dropped in water. Zoe disagrees. Using THREE physical properties from her observations, explain why Zoe is correct — and connect her reasoning to why scientists use MULTIPLE properties to identify matter rather than just one.

Answer Key: Zoe and the Secret Lair of Matter

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Before Q6, hold up two mystery cups — one with sand and one with salt — and ask students which one Zoe could dissolve in water to escape the villain trap. This directly mirrors Q6 and activates prior knowledge about solubility as a physical property.

1. Zoe enters the secret lair and spots two power crystals on a table. One crystal is hard and clear. The other is soft and cloudy. Hardness and color are physical properties of matter. True or False: Hardness and color describe what a material IS MADE OF.

Answer: Q1: Hardness and color are physical properties — they describe how matter looks or feels. They do NOT tell us what a material is made of (that would be its chemical identity). Answer = FALSE. Hardness and color describe the appearance and feel of matter, not its composition.

2. Zoe picks up her hero badge. The badge is a solid. Which best describes a solid? A) It has a definite shape and definite volume. B) It has no definite shape but definite volume. C) It has no definite shape and no definite volume.

Answer: Q2: A solid has particles packed tightly together — it holds its own shape and takes up a fixed amount of space (definite volume). Option B describes a liquid. Option C describes a gas. Answer = A. A solid has a definite shape and definite volume.

3. Zoe finds a villain trap filled with a mystery liquid. She notices the liquid takes the shape of its container but keeps the same volume. She also sees it does NOT dissolve the metal walls. Name TWO physical properties Zoe just observed about this liquid.

Answer: Q3: Observation 1 — The liquid takes the shape of its container but keeps its volume. This tells us its STATE OF MATTER = liquid. Observation 2 — It does not dissolve the metal walls. This tells us its SOLUBILITY in metal = zero (it is not soluble in metal). Answer = State of matter (liquid) AND solubility (does not dissolve metal). Both are physical properties because no new substance was formed during observation.

4. Zoe places a power crystal in water. The crystal sinks straight to the bottom. Zoe knows water has a density of 1 g/cm³. What does the crystal sinking tell Zoe about the crystal's density compared to water's density? Explain using the word DENSITY.

Answer: Q4: Objects sink when they are denser than the liquid they are placed in. Water density = 1 g/cm³. The crystal sinks → crystal density is GREATER THAN 1 g/cm³. Answer = The crystal's density is greater than 1 g/cm³ (greater than water). Density is a physical property — it compares mass to volume — and Zoe used it as evidence to identify the crystal without changing it.

5. Inside the secret lair, Zoe compares two substances. Substance A dissolves completely in water. Substance B does not dissolve at all. Zoe heats both substances. Substance A boils at 100°C. Substance B melts at 1,538°C. Use TWO properties to explain which substance is most likely iron.

Answer: Q5: Iron is a metal with a very high melting point (1,538°C) and is NOT soluble in water. Substance B has a melting point of 1,538°C AND does not dissolve in water — both properties match iron. Substance A dissolves in water and boils at 100°C, which matches water itself, not iron. Answer = Substance B is most likely iron because its melting point (1,538°C) and insolubility in water are both physical properties that match iron. Using two properties together gives stronger evidence than one alone.

6. Zoe is trapped inside the villain's lair. The only exit is sealed with a lock made of a white powder. Zoe has two options: powder X (salt, soluble in water) or powder Y (sand, insoluble in water). She has a bottle of

water. Zoe needs to dissolve the powder to unlock the door. Which powder should Zoe choose, and why is solubility a physical property and NOT a chemical property?

Answer: Q6: Zoe should choose Powder X (salt) because salt is SOLUBLE in water — it dissolves and could be used to open the lock. Sand (Powder Y) is insoluble — it will not dissolve. Solubility is a PHYSICAL property because when salt dissolves in water, NO new substance is created. The salt can be recovered by evaporating the water — the salt molecules are still salt. A chemical property would involve a chemical change that creates a new substance (like burning or rusting). Answer = Powder X (salt); solubility is a physical property because dissolving does not create a new substance.

7. Zoe discovers a glowing gas leaking from a pipe in the secret lair. The gas has no color, no odor, and a very low density. When Zoe holds a flame near the gas, it burns and produces water vapor — a new substance forms. Identify one physical property AND one chemical property of this gas. Explain how you know which is which.

Answer: Q7: Physical property — The gas has no color and low density. These are physical properties because they describe the gas AS IT IS without changing it into something else. You can observe color and estimate density without starting a reaction. Chemical property — The gas burns and produces water vapor (a new substance). This is a chemical property because it describes how the gas REACTS and CHANGES into a different substance. Burning is a chemical change. The gas described matches hydrogen gas (colorless, low density, burns to form water). Answer = Physical property: colorless / low density. Chemical property: flammability (it burns and forms a new substance, water vapor). A property is chemical when observing it requires a chemical change.

8. Zoe has defeated the villain and holds the final power crystal — her mission is complete. She writes her lab report. The crystal is purple, hard, does not dissolve in water, has a density of 3.5 g/cm^3, and does NOT burn. Another hero claims the crystal changed into a new substance when it was dropped in water. Zoe disagrees. Using THREE physical properties from her observations, explain why Zoe is correct — and connect her reasoning to why scientists use MULTIPLE properties to identify matter rather than just one.

Answer: Q8: Zoe's three physical properties as evidence — (1) The crystal did not dissolve in water: solubility = insoluble. No new substance formed, so no chemical change occurred. (2) The crystal's density = 3.5 g/cm^3: density is measured without changing the crystal. It stayed the same before and after water contact. (3) The crystal did not burn: this confirms no chemical reaction with the flame, meaning the crystal kept its identity. Because all three properties remained unchanged after the crystal was placed in water, Zoe correctly concludes no new substance was formed — it was NOT a chemical change. Why multiple properties matter: One property alone can be misleading. For example, many different substances can be purple. But a substance that is purple AND has density 3.5 g/cm^3 AND is insoluble AND non-flammable is identified with much greater certainty. Scientists use multiple properties together as a fingerprint to positively identify matter — this is exactly how real chemists and materials scientists identify unknown substances in labs today. Answer = Zoe is correct. Three physical properties (insolubility, density of 3.5 g/cm^3, non-flammability) all remained unchanged, proving no new substance formed. Scientists use multiple properties because each additional property narrows the identity of matter and reduces the chance of a false match.