

Forces You Cannot See

Use bulk-scale evidence to infer particle attractions.

HS-PS1-3 "Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles..."

NAME _____

DATE _____

1 READ AND MARK _____ Read it twice

YOUR JOB Underline each bulk property being measured, circle each controlled variable, and number each statement that links an observation to stronger or weaker electrical forces between particles.

Evidence from Everyday Properties

- ① Two unlabeled solids sit in separate jars. To compare the electrical forces holding their particles together, a class can investigate melting behavior. The class should first make a plan that keeps the test fair. Use equal-sized samples, the same type of heating equipment, and the same heating rate. Measure each sample's temperature regularly while heating, then record the temperature range where each solid changes into a liquid. A substance that remains solid until a higher temperature generally has particles held by stronger electrical forces. This inference compares bulk evidence, not a direct view of individual particles.
- ② Another group can collect evidence from liquids without boiling them. Place equal volumes of each liquid in identical open containers, keep both containers at the same temperature, and measure mass loss over the same time. Faster mass loss indicates that more particles escape from the liquid surface. At one temperature, the liquid with the greater tendency to escape has higher vapor pressure and usually weaker electrical forces between its particles. The comparison is strongest when temperature, container shape, starting volume, and time are controlled. Repeating trials makes the evidence more reliable, because one unusual measurement may be an error.
- ③ Surface tension offers a third kind of bulk-scale evidence. Carefully add drops of a liquid to the top of the same clean coin, using the same dropper and method for every trial. Count the drops just before the liquid spills. A liquid that forms a taller rounded dome and holds more drops generally has stronger electrical attractions among particles at its surface than a liquid that spills sooner. This result alone does not identify particle type or name a force. Scientists combine several measurements, such as melting temperature, vapor pressure, and surface tension, to support an inference. A good conclusion states evidence, comparison, and one limit.

2 ANSWER WITH EVIDENCE Use the passage

1 Name two variables that should be controlled in the melting investigation. Why must they be controlled?

2 In the heating investigation, what observation would support an inference of stronger electrical forces between particles?

3 At the same temperature, Liquid A loses mass faster than Liquid B from identical open containers. What inference does the passage support about their particle forces?

4 Why should scientists repeat trials, and what can a surface-tension test not determine by itself?

3 YOUR TURN Your own words

Design an investigation to compare two unknown substances using one bulk property from the passage. State what you will measure, at least two controls, what result would support stronger electrical forces, and one limit of your investigation.

PART 1 • READ AND MARK

Underline each bulk property being measured, circle each controlled variable, and number each statement that links an observation to stronger or weaker electrical forces between particles. Accept any marking that follows this job and points at the right text.

PART 2 • ANSWERS

#	QUESTION	ANSWER
1	Name two variables that should be controlled in the melting investigation. Why must they be controlled?	Any two of these: sample size, heating equipment type, and heating rate. They must be controlled so differences in melting behavior can be attributed to the substances rather than the test conditions.
2	In the heating investigation, what observation would support an inference of stronger electrical forces between particles?	The substance remains solid until a higher temperature, or has a higher melting temperature range.
3	At the same temperature, Liquid A loses mass faster than Liquid B from identical open containers. What inference does the passage support about their particle forces?	Liquid A has higher vapor pressure and usually weaker electrical forces between its particles than Liquid B.
4	Why should scientists repeat trials, and what can a surface-tension test not determine by itself?	Repeating trials reduces the effect of an unusual measurement or error. A surface-tension test alone cannot identify the particle type or name the electrical force.

PART 3 • YOUR TURN (SAMPLE ANSWER)

I will add drops of unknown liquids A and B to identical clean coins with the same dropper, counting drops at spill while keeping the coin, dropper, temperature, and method constant. If A holds more drops before spilling in repeated trials, I will infer stronger electrical forces between A's surface particles; this test cannot identify the particles or name the force.

Accept feasible investigations using melting behavior, mass loss as evidence of vapor pressure, or surface tension, as long as controls and an evidence-based inference are included. Accept equivalent statements that stronger forces are supported by higher melting temperature, slower mass loss, or more drops held before spilling.