Magnet Bench Mysteries

Connect visible magnetic behavior to what happens inside a material.

HS-PSII-6.1 "Describe the magnetic properties of ferromagnetic, paramagnetic, and diamagnetic materials on a macroscopic scale and atomic scale."

NAME _____ DATE _____

1 READ AND MARK

Read it twice

YOUR JOB Underline what the magnet does to each material, and circle the words that explain what happens inside it. Number each underlined behavior and its matching explanation with the same number.

Three Materials, One Magnet

(1) At a repair bench, a magnet pulls an iron screw across a sheet of paper. Iron is ferromagnetic: its atoms have magnetic moments, mainly from electron spin, that cooperate in groups called domains. Within each domain, many moments point the same way. Before the magnet approaches, domains may face different directions, so the screw as a whole has little magnetic effect. The nearby field makes favorably oriented domains grow and other moments turn. The screw is strongly attracted. After the magnet leaves, some alignment may remain, making the screw itself a magnet.

(2) At the same bench, an aluminum strip barely moves toward a strong magnet. Aluminum is paramagnetic. Its atoms have unpaired electrons that give them magnetic moments, but the moments do not form stable, cooperative domains like those in iron. With no applied field, thermal motion leaves their directions disordered, so the strip has no lasting magnetization. In the field, slightly more moments point with the field than against it. This small imbalance produces weak attraction, not the dramatic pull of the screw. When the magnet goes away, the moments lose that slight alignment, and the magnetization vanishes.

(3) A crystal of table salt on the bench behaves differently: in a sufficiently strong field, it is weakly pushed away. Table salt is diamagnetic. Its ions have paired electrons, so they do not have lasting net magnetic moments from unpaired electrons. Instead, an applied magnetic field changes electron motion slightly and induces magnetic moments that oppose the field. That opposition causes a weak repulsion, which disappears when the field is removed. Diamagnetism exists in all materials, but stronger magnetic responses overwhelm it in iron and aluminum. An ordinary hand magnet may not make the crystal's movement visible without sensitive equipment.

2 ANSWER WITH EVIDENCE

Use the passage

1. Sample A is pulled strongly toward a magnet and remains magnetized after the magnet is removed. Which material class fits these observations? Explain what happened inside Sample A.

2. Sample B is weakly attracted to a magnet but has no lasting magnetization. Identify its material class and explain its behavior at the atomic scale.

3. Sample C is weakly repelled by a strong magnet. Identify its material class and explain both the repulsion and what happens when the field is removed.

4. Two samples are attracted to a magnet. One is pulled strongly; the other is pulled weakly. How could their atomic-scale behavior explain the difference?

3 YOUR TURN

Your own words

Design a three-part museum display that uses one ferromagnetic, one paramagnetic, and one diamagnetic material near a magnet. Describe what visitors would observe for each material while the field is on and after it is removed, and explain each result using atomic-scale behavior.

ANSWER KEY

Magnet Bench Mysteries

HIGH SCHOOL · HS-PSII-6.1

PART 1 · READ AND MARK

Underline what the magnet does to each material, and circle the words that explain what happens inside it. Number each underlined behavior and its matching explanation with the same number. Accept any marking that follows this job and points at the right text.

PART 2 · ANSWERS

#	QUESTION	ANSWER
1	Sample A is pulled strongly toward a magnet and remains magnetized after the magnet is removed. Which material class fits these observations? Explain what happened inside Sample A.	**Ferromagnetic. Its cooperative magnetic domains became more aligned in the field, and some alignment remained afterward.**
2	Sample B is weakly attracted to a magnet but has no lasting magnetization. Identify its material class and explain its behavior at the atomic scale.	**Paramagnetic. Unpaired electrons give its atoms magnetic moments that align slightly with the applied field but become disordered again when it is removed.**
3	Sample C is weakly repelled by a strong magnet. Identify its material class and explain both the repulsion and what happens when the field is removed.	**Diamagnetic. The field induces magnetic moments that oppose it, causing weak repulsion. The induced moments disappear when the field is removed.**
4	Two samples are attracted to a magnet. One is pulled strongly; the other is pulled weakly. How could their atomic-scale behavior explain the difference?	**The strongly attracted sample may be ferromagnetic, with magnetic moments cooperating in domains. The weakly attracted sample may be paramagnetic, with individual moments aligning only slightly in the field.**

PART 3 · YOUR TURN (SAMPLE ANSWER)

I would place three labeled samples near a strong magnet and use sensors to show small forces. The ferromagnetic sample would move strongly toward the magnet because its domains align cooperatively; some alignment might remain afterward. The paramagnetic sample would show weak attraction as its unpaired-electron moments align slightly. That alignment would disappear when the field is removed. The diamagnetic sample would show weak repulsion because the field induces opposing magnetic moments. Its repulsion would also disappear without the field.

Accept explanations that link each visible response to domains, slight alignment of moments from unpaired electrons, or induced opposing moments. Ferromagnetic materials can retain magnetization, but they do not always do so.