

Magnetism

Magnetism

- Magnetism is caused by two sources: (1) electric current (moving electric charges) or (2) many particles have “intrinsic” or “spin magnetic moments. Particles have mass, charge and a certain magnetic “moment.”

Electric currents (moving electric charges) produce magnetic fields

- Lines of magnetic field due to an electric current in a straight wire form circles around the wire. These circles are perpendicular to the wire.
- For conventional current (flow of positive charges) use the “right hand rule” with the right thumb pointing in the direction of the conventional (positive) current and the fingers curling showing the magnetic field direction.
- This field exerts a force on magnets.

Ferromagnetic Materials

- Some elements have unpaired electrons (in unfilled orbitals) that may “line up” and have the same spin.
- Transition Metals: ^{26}Fe , ^{27}Co and ^{28}Ni have unpaired “d” orbital electrons that may line up and have the same spin.
- Rare earth elements: ^{60}Nd and ^{64}Gd have unpaired “f” orbital electrons that may line up and have the same spin.
- Strongest magnetic compound: $\text{Nd}_2\text{Fe}_{14}\text{B}$

Non-magnetic Materials

- Non-magnetic materials do NOT have unpaired electrons. Their electron orbitals are filled according to the Pauli exclusion principle. These electrons have spins that cancel each other out.
- Examples: plastic, noble gases (He, Ne and Ar)

How to destroy a magnet

- Heat (high temperature). Heat destroys a magnet presumably because high temperature agitates and causes motion and makes it difficult for unpaired electrons to have the same spin near each other in domains. (Example: Curie temperature)
- Shattering/blunt force. Blunt force destroys a magnet presumably because shattering dislodges/disturbs/agitates the atoms and the domains containing the unpaired electrons.

Bar magnets

- Each bar magnet has two poles: north and south. North pole of a magnet points toward the magnetic south pole; south pole of a magnet points toward the magnetic north pole.
- Magnetic fields are strongest at the poles.
- Magnetic field lines are loops starting at north
- Magnetic field lines visualized by the north pole of a compass (points from north to south).

Attraction/Repulsion

- LIKE poles REPEL each other.
- UNLIKE poles ATTRACK each other.
- Magnetic field strength greatest near each pole.

If you cut a magnet in half, what happens?

- If you cut a magnet in half, you get two magnets. Each half-piece has a north pole and a south pole.

Magnetic Field Lines

- Magnetic field is greatest at the poles.
- Use the north pole of a compass to trace and map magnetic field lines.
- Magnetic field lines point *AWAY* from North and *TOWARD* the south pole.
- Example: A bar magnet has one end as its north pole and the opposite end as its south pole. The field lines are loops starting from north and going toward south.

Domains

- Domains are tiny permanent magnets.
- Domains are tiny regions of atoms approximately 1 mm in diameter. These atoms with their unpaired electrons stick together and align themselves together.
- When exposed to a magnetizing field, the domains align with the magnetic field and grow. Thus, the material has become a permanent magnet.

Magnetic Monopole

- Single, separate, isolated magnetic pole.
- ORDINARILY, NOT FOUND IN NATURE.
- Recent report by Professor David Hall et al.
From Amherst College in January, 2014 Nature
- Claim: They synthesized an isolated magnetic pole with magnetic charge and point-like source of magnetic field.

Group Activity

- 1. Clearly and carefully draw two bar magnets that are attracted to each other. Label the poles. Show magnetic field lines.
- 2. Clearly and carefully draw two bar magnets that are repelled from each other. Label the poles. Show magnetic field lines.
- Clearly and carefully draw a horseshoe magnet. Label the poles. Show magnetic field lines.