Ferromagnetism

Observations in Everyday Life:

Certain iron ores (*loadstone* or *magnetite*, Fe_3O_4) attract small pieces of iron. Any substance with this property is called *magnet* (after the Greek city of Magnesia).

Magnets can attract or repel each other.

A compass needle always points to the north.

(Ferro-) Magnetism:

The fact that magnetic forces act on iron is called *ferromagnetism*.

Magnetic Poles:

Similar to the situation in electrostatics, there are two types of magnetic "charges": the magnetic *poles*.

Every magnet has two different poles, a *north pole* and a *south pole*.

Like poles repel each other, and unlike poles attract.

There are no magnetic monopoles, i.e. no isolated north or south poles. If a magnet is cut in halves, each half possesses both poles again.

In addition to magnetic *dipoles*, there are higher order poles (e.g. *quadrupoles* or *octopoles*)

Contrary to electric charges, magnetic poles are not attached to freely moving charge carriers and therefore cannot easily be transferred from one body to another.

Magnetic Attraction and Shielding:

Objects made of *iron*, *nickel*, *cobalt*, as well as alloys and compounds of these metals are attracted by a magnet, they are said to be *magnetisable*.

Magnetic fields can be shielded with a magnetisable plate.

Elementary Magnets (Ampère):

Magnetisable substances consist of elementary magnets, which are oriented randomly. Therefore, there is no discernable magnetic effect on a macroscopic scale.

In a *permanent* magnet on the other hand, the elementary magnets are all oriented in the same direction, thus mutually amplifying the magnetic effect.

Ferromagnetic Domains (Weiss Domains)

In ferromagnetic substances, the elementary magnets are oriented in the same direction across regions of typically 10^{17} – 10^{21} atoms, the *ferromagnetic* (or *Weiss*) *domains*. By aligning the ferromagnetic domains (e.g. in an external magnetic field), the object can be permanently magnetised (*remanence*).

To demagnetise a permanent magnet, the alignment of the ferromagnetic domains has to be destroyed, which can be done by heating the object over a characteristic temperature (*Curie temperature*).

Magnetic Influence:

The elementary magnets in a magnetisable object placed near a permanent magnet align in the direction of the external field. As a consequence, the object becomes a (temporary) magnet itself, but loses this property as soon as the permanent magnet is removed.