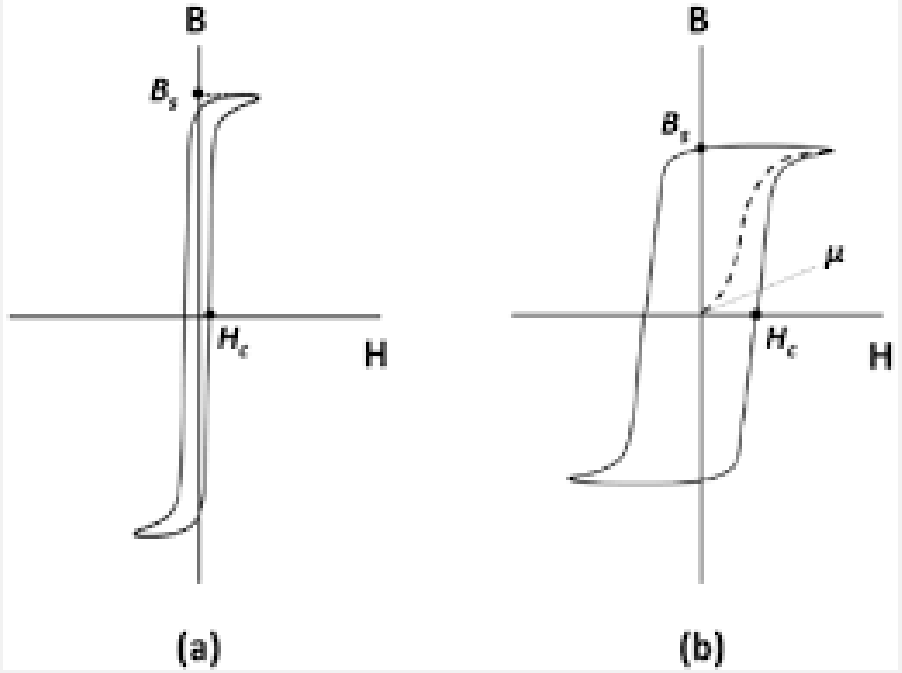
MAGNETIC MATERIALS

CLASSIFICATION: MECHANIC RESPONSE

Soft	Hard
Easily magnetized	Almost impossible to magnetized
Lose of magnetic behavior	Don’t lose magnetic behavior
Large values of susceptibility and permeability	Small values of permeability and susceptibility
Electromagnets	Permanent magnets
Fe-Si, Fe-Ni, ferrites…	Fe-Ni-Al, Co-Alloys

MAGNETIC FIELD, PERMEABILITY AND MAGNETIZATION



- Electric current through a coil with n turns produces a magnetic field.

$$H = n\frac{I}{l}$$

- n: number of turns
- l: length of the coil (m)
- I: is the current (A).
- H: Magnetic field (A/m) or oersted

  4πE-3 oersted = A/m

MAGNETIC FIELD, PERMEABILITY AND MAGNETIZATION

- Permeability

$$\mu_r = \frac{\mu}{\mu_0}$$

$\mu > \mu_0$ If the magnetic moments are in the same direction of the applied field.

$\mu < \mu_0$ If the magnetic moments oppose the field.

μ_0: 4πE-7 H/m

- Magnetization

$$B = \mu_0 H$$

$$B = \mu H;\ B = \mu H + \mu M$$

$$X_m = \frac{M}{H} = \mu_r - 1$$

X_m: Magnetic susceptibility

M: Magnetization (A/m)

B: inductance (H or Teslas)

Moment of electrons: Bohr magneton ($9.27 \times 10^{-24}\ A \cdot m^2$)

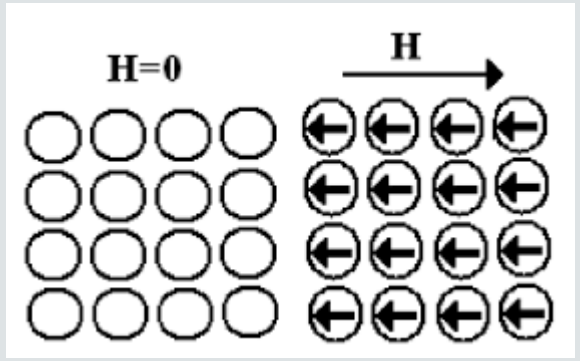
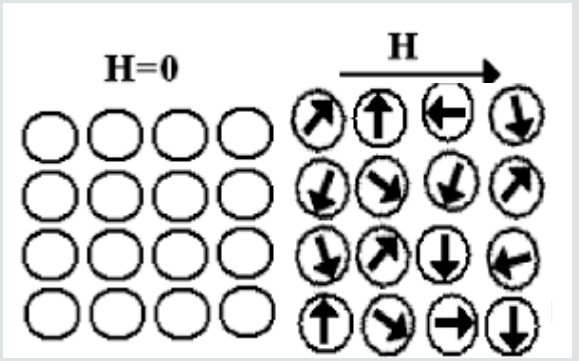
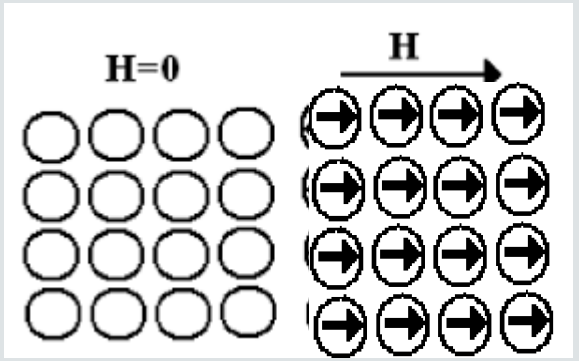
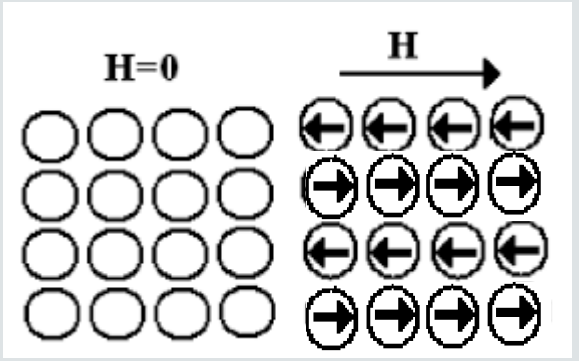
EXAMPLE

Estimate the magnetization that might be produced in an alloy containing nickel and 70 at% copper, assuming that no interaction occurs.

- $a_0(Ni) = 3.52 \times 10^{-10}$ m
- $a_0(Cu) = 3.61 \times 10^{-10}$ m

CLASSIFICATION: MAGNETIC RESPONSE

Curie Temperature: T at which ferromagnetic become paramagnetic.
Above this temperature, ferrimagnetic become paramagnetic

Diamagnetism	Paramagnetism	Ferromagnetism	Ferrimagnetism
Induced opposite magnetic dipole	Induced random magnetic dipole	Induced magnetic dipole	Induced magnetic dipole both parallel and opposite
Opposing magnetic fields	No interaction among dipoles	Amplify magnetic field	Amplify magnetic field
			
Gold, silver, copper, mercury	Calcium, aluminum, chromium	Iron, Cobalt	Zinc, Nickel and ceramics

APPLICATION: SOFT MAGNETS

Field of application	Products	Requirements	Materials
Power conversion electrical - mechanical	Motors Generators Electromagnets	Large **M** Small **H** Low losses **=** small conductivity low	**Fe** based materials, e.g. **Fe + Si** **Fe + Co**
Power adaption	(Power) Transformers		
Signal transfer	Transformer ("Überträger")	Linear **M - H** curve	

APPLICATION: HARD MAGNETS

Field of application	Products	Requirements	Materials
Permanent magnets	Loudspeaker Small generators Small motors Sensors	Large $\mathbf{H_C}$ (and $\mathbf{M_R}$)	**Fe/Co/Ni/Al/Cu** **$SmCo_5$** **Sm_2Co_{17}**
Data storage analog	Video tape Audio tape	Medium $\mathbf{H_C}$(and $\mathbf{M_R}$), hystereses loop as rectangular as possible	**NiCo**, **CuNiFe**, **CrO_2** **Fe_2O_3**
Data storage digital	Ferrite core memory Drum