PHYSICS

BOOKS - HC VERMA

MAGNETIC PROPERTIES OF MATTER

Examples

1. A bar magnet made of steel has a magnetic moment of $2.5Am^2$ and amass of $6.6 \times 10^{-3}kg$. If the density of steel is

$7.9 \times 10^3 kgm^{-3}$, find the intensity of magnetization of the magnet.

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2. Find the magnetic intensity H at the centre of a long solenoid having n turns per unit length and carrying a current i (a) when no material is kept in it and (b) when a long copper rod is inserted in the solenoid.

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3. Find the per cent increase in the magnetic field B when the space within a current-carrying toroid is filled with aluminiu. The susceptibility of aluminium is 2.1×10^{-5}.

A. 0.021

B. 0.00021

C. 0.0021

D. 2.1

Answer: C

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Worked Out Examples

1. A tightly-wound, long solenoid having 50 turns cm^{-1}, carris a current of $4.00A$. Find the magnetic intensity H and the magnetic field B at the centre of the solenoid. What will be the values of these quantities if an iron core is inserted in the solenoid and the magnetization I in the core is $4.00 \times 10^{6} Am^{-1}$?

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2. A long, cylindrical iron core of cross-sectional area $5.00cm^2$ is inserted into a long solenoid having 2000 tunres m^{-1} and carrying a current $2.00A$. The magnetic field inside the core is found to be $1.57T$. Neglecting the end effects, find the magnetization I of the core and the pole strength developed.

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3. An ideal solenoid having 40 turns cm^{-1} has an aluminium core and carries a current of $2.0A$. Calculate the magnetization I developed in the core and the magnetic field B at the centre. The susceptibility χ of aluminium $= 2.3 \times 10^{-5}$.

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4. Find (a) the magnetization I, (b) the magnetic intensity H and (c) the magnetic field B at the centre of a bar magnet having

pole strength $3.6Am$, magnetic length $12cm$ and cross-sectional are $0.90cm^2$.

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5. The maximum value of the permeability of μ metal (77% Ni, 16% Fe, 5% Cu, 2% Cr) is $0.126TmA^{-1}$. Find the maximum relative permeability and susceptibility.

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6. A toroid has a mean radius R equal to $\frac{20}{\pi}$ cm, and a total of 400 turns of wire carrying a current of $2.0A$. An aluminium ring at temperature $280K$ inside the toroid provides the core. (a) If the magnetization I is $4.8 \times 10^{-2} Am^{-1}$, find the susceptibility of aluminium at $280K$. (b) If the temperature of the aluminium ring is raised to $320K$, what will be the magnetization?

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Short Answer

1. When a dielectric is placed in an electric field, it gets polarized. The electric field in a polarized material is less than the applied field. When a paramagnetic substance is kept in a magnetic field, the field in the substance is more than the applied field. Explain the reason of this opposite behaviour.

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2. The property of diamagnetism is said to be present in all materials. Then, why are some materials paramagnetic or ferromagnetic?

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3. Do permeability and relative permeability have the same dimensions?

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4. A rod when suspended in a magnetic field stays in east-west direction. Can we be sure that the field is in the east-west direction? Can it be in the north-south direction?

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5. Why cannot we make permanent magnets from paramagnetic materials?

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6. Can we have magnetic hysterisis in paramagnetic or diamagnetic substances?

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7. When a ferromagnetic material goes through a hysteresis loop, its theremal energy is increased. Where does this energy come from?

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8. What are the advantagges of using soft iron as a core, instead of steel, in the coils of galvanometers?

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9. To keep valuable instruments away from the earth's magnetic field, they are enclosed in iron boxes. Explain.

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Objective 1

1. A paramagnetic material is placed in a magnetic field. Consider the following statements : (A) If the magnetic field is increased, the magnetization is increased. (B) If the temperature is increased, the increased the magnetization is increased.

A. Both A and B are ture

B. A is true but B is false

C. B is true but A is false

D. Both A and B are false.

Answer: B

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2. A paramagnetic material is kept in a magnetic field. The field is increased till the magnetization becomes constant. If the temperature is now decreased, the magnetization.

A. will increase

B. decrease

C. remain constant

D. may increase or decrease

Answer:

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3. A ferromagnetic material is placed in an external magnetic field. The magnetic domains

A. increase in size

B. decrease in size

C. may increase or decrease in size

D. have no relation with the field.

Answer: C

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4. A long, straight wire carries a current i. The magnetizing field intensity H is measured at a point P close to the wire. A long, cylindrical iron rod is brought close to the wire so that

the point P is at the centre of the rod. The value of H at P will

A. increase many times

B. decrease many times

C. remain almost constant

D. become zero

Answer: C

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5. The magnetic susceptibility is negative for

A. paramagnetic materials only

B. diamagnetic materials only

C. ferromagnetic materials only

D. paramagnetic and ferromagnetic materials.

Answer: B

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6. The desirable properties for making permanent magnets are

A. high retentivity and high coercive force

B. high retentivity and low coercive force

C. low retentivity and high coercive force

D. low retentivity and low coercive force.

Answer: A

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7. Electromagnets are made of soft iron because soft iron has

A. high retentivity and high coercive force

B. high retentivity and low coercive force

C. high retentivity and high coercive force

D. low retentivity and low coercive force.

Answer: D

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Objective 2

1. Pick the correct option

A. All electrons have magnetic moment

B. All protons have magnetic moment

C. All nuclei have magnetic moment.

D. All atoms have magnetic moment.

Answer: A::B

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2. The permanent magnetic moment of the atoms of a material is not zero. The material

A. must be paramagnetic

B. must be diamagnetic

C. must be ferromagnetic

D. may be paramagnetic

Answer: D

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3. The permanent magnetic moment of the atoms of a material is zero. The material

A. must be paramagnetic

B. must be diamagnetic

C. must be ferromagnetic

D. may be paramagnetic

Answer: B

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4. Which of the following pairs has quantities of the same dimensions?

A. Magnetic field B and magnetizing field intensity H

B. Magnetic field B and intensity of magnetization I

C. Magnetizing field intensity H and intensity of magnetization I

D. Longitudinal strain and magnetic susceptibility

Answer: C::D

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5. When a ferromagnetic material goes through a hysteresis loop, the magnetic susceptibility

A. has a fixed value

B. may be zero

C. may be infinity

D. may be negative

Answer: B::C::D

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6. Mark out the correct options.

A. Diamagnetism occurs in all materials

B. Diamagnetism results from the partial alignment of permanent magnetic moment.

C. The magnetizing field intensity H is always zero in free space.

D. The magnetic field of induced magnetic moment is opposite to the applied fied.

Answer: A::D

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Exercises

1. The magnetic intensity H at the centre of a long solenoid carrying a current of $2.0A$, is found to be $1500Am^{-1}$. Find the number of turns per centimetre of the solenoid.

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2. A rod is inserted as the core in the current-carrying solenoid of the previous problem. (a) What is the magnetic intensity H at the

centre? (b) If the magnetization I of the core is found to be $0.12Am^{-1}$, find the susceptibility of the material of the rod. (c) Is the material paramagnetic, diamagnetic or ferromagnetic?

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3. The magnetic field inside a long solenoid having 50 turns cm^{-1} is increased from $2.5 \times 10^{-3}T$ to $2.5T$ when an iron core of cross-sectional area $4cm^2$ is inserted into it.

Find (a) the current in the solenoid, (b) the magnetization I of the core and (c) the pole strength developed in the core.

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4. A bar magnet of length $1cm$ and cross-sectonal area $1.0cm^2$ produces a magnetic field of $1.5 \times 10^{-4}T$ at a point in end-on position at a distance 15cm away from the centre. (a) Find the magnetic moment M of the magnet. (b) Find the magnetization I of

the magnet. (c) Find the magnetic field B at the centre of the magnet.

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5. The susceptibility of annealed iron at saturation is 5500. Find the permeability of annealed iron at saturation.

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6. The magnetic field B and the magnetic intensity H in a material are found to be $1.6T$ and $1000Am^{-1}$ respectively. Calculate the relative permeability μ, and the susceptibiliyt χ of the material.

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7. The susceptibility of magnesium at $300K$ is 1.2×10^{-5}. At what temperature will the susceptibility increase to 1.8×10^{-5}?

A. $200K$

B. $250K$

C. $400K$

D. $150K$

Answer: A

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8. Assume that each iron atom has a permaanent magnetic moment equal to 2 Bohr magnetons

$(1Bohrmag \neq \rightarrow nequals 9.27 \times 10^{-24} Am^2)$. The density of atoms in iron is $8.52 \times 10^{28} a \rightarrow ms \quad m^{-3}$. (a) Find the maximum magnetization I in a long cylinder of iron. (b) Find the maximum magnetic field B on the axis inside the cylinder.

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9. The coercive force for a certain permanent magnet is $4.0 \times 10^4 Am^{-1}$. This magnet is placed inside a long solenoid of 40 turns/cm

and a current is passed in the solenoid to demagnetize it completely. Find the current.

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