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ESE-2025 : Preliminary Examination
Electrical Engineering : Volume-1
Topicwise Objective Solved Questions : (2001-2024)

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Director's Message

B. Singh (Ex. IES)

Engineering is one of the most chosen graduating field. Taking engineering is usually a matter of interest but this eventually develops into "purpose of being an engineer" when you choose engineering services as a career option.

Train goes in tunnel we don't panic but sit still and trust the engineer, even we don't doubt on signalling system, we don't think twice crossing over a bridge reducing our travel time; every engineer has a purpose in his department which when coupled with his unique talent provides service to mankind.

I believe *"the educator must realize in the potential power of his pupil and he must employ all his art, in seeking to bring his pupil to experience this power"*. To support dreams of every engineer and to make efficient use of capabilities of aspirant, MADE EASY team has put sincere efforts in compiling all the previous years' ESE-Pre questions with accurate and detailed explanation. The objective of this book is to facilitate every aspirant in ESE preparation and so, questions are segregated chapterwise and topicwise to enable the student to do topicwise preparation and strengthen the concept as and when they are read.

I would like to acknowledge efforts of entire MADE EASY team who worked hard to solve previous years' papers with accuracy and I hope this book will stand up to the expectations of aspirants and my desire to serve student fraternity by providing best study material and quality guidance will get accomplished.

B. Singh (Ex. IES)
CMD, MADE EASY Group

Volume-I

ELECTRICAL ENGINEERING

Objective Solved Questions

of UPSC Engineering Services Examination

Contents

■■■■

UNIT

I

Electrical Materials

Syllabus

Electrical engineering materials, crystal structures and defects, ceramic materials, insulating materials, magnetic materials-basics, properties and applications, ferrities, ferro-magentic materials and components, basics of solid state physics, conductors, photo-conductivity, basics of nano materials and superconductors.

Contents

❍❍❍❍

3 Magnetic Properties of Materials

3.1 A large value of the exchange interaction energy in a ferromagnetic material implies
(a) Large saturation magnetization
(b) High Curie temperature
(c) High melting point
(d) Large diamagnetic susceptibility

[ESE-2001]

3.2 Which one of the following pairs is NOT correctly matched ?
(a) Copper : Diamagnetic
(b) Sodium : Anti ferromagnetic
(c) Iron : Ferromagnetic
(d) Ferrite : Ferrimagnetic

[ESE-2001]

3.3 Ferromagnetic behaviour is shown by those transition metals where the ratio of the atomic diameter to 3d orbital diameter is
(a) in the range of 0.5 to 1
(b) in the range of 1 to 1.5
(c) in the range of 1.5 to 2
(d) greater than 2

[ESE-2001]

3.4 Ferrites can be considered as mixed oxides of metals A and B having inverse spinel structure. Their formula can be written as
(a) ABO_2 (b) A_2BO_2
(c) AB_2O_3 (d) AB_2O_4

[ESE-2001]

3.5 Match **List-I** (Magnetic materials) with **List-II** (Main applications) and select the correct answer:

List-I
A. Ni-Zn ferrite
B. Co-Sm alloy
C. Yttrium Iron Garnet
D. Mg-Zn ferrite

List-II
1. Recording head
2. Permanent magnets
3. Audio and TV transformers
4. Memory cores
5. Microwave isolators

Codes:

	A	B	C	D
(a)	3	4	5	2
(b)	1	2	3	4
(c)	3	2	5	4
(d)	1	4	3	2

[ESE-2001]

3.6 Match **List-I (Type of the material)** with **List-II (Name of the material)** and select the correct answer:

List-I	List-II
A. Ferroelectric material	**1.** Permalloy
B. Piezoelectric material	**2.** $BaTiO_3$ ceramic
C. Soft magnetic material	**3.** KH_2PO_4
D. Hard magnetic material	**4.** Tungsten steel

Codes:

	A	B	C	D
(a)	3	2	1	4
(b)	1	4	3	2
(c)	3	4	1	2
(d)	1	2	3	4

[ESE-2002]

3.7 Which one of the following materials can not be used for permanent magnets?
(a) Alnico (b) Barium Ferrite
(c) Carbon-Steel (d) Iron-Cobalt alloy

[ESE-2002]

3.8 Upto about 4% silica is added in iron to be used as a soft magnetic material. The major reason for this is to

(a) increase permeability of the material
(b) increase electrical resistivity of the material
(c) increase the coercive force
(d) increase the saturation flux density

[ESE-2002]

3.9 Susceptibility of a diamagnetic material is
1. Negative
2. Positive
3. Dependent on the temperature
4. Independent of the temperature

Select the correct answer using the codes given below:
(a) 1 and 3 (b) 2 and 4
(c) 1 and 4 (d) 2 and 3

[ESE-2003]

3.10 Match **List-I** (Magnetic Materials) with **List-II** (Applications) and select the correct answer:

List-I	List-II
A. Silicon Steel	1. Current transformer
B. Ferrite	2. Power transformer
C. Alnico	3. Permanent magnet
	4. High frequency transformer

Codes:

	A	B	C
(a)	1	2	3
(b)	1	4	2
(c)	2	1	4
(d)	2	4	3

[ESE-2003]

3.11 Match **List-I** with **List-II** and select the correct answer using the codes given below:

List-I	List-II
A. Larmor frequency	1. $\chi = C/(T-\theta)$
B. Bohr magneton	2. $B = \mu_0(H + M)$
C. Magnetic induction	3. $eh/4\pi$ m
D. Curie-Weiss law	4. $eB/2$ m

Codes:

	A	B	C	D
(a)	2	1	4	3
(b)	2	3	4	1
(c)	4	1	2	3
(d)	4	3	2	1

[ESE-2004]

3.12 Which one of the following is the temperature below which certain material are anti-ferromagnetic and above which they are paramagnetic?
(a) Curie temperature
(b) Neel temperature
(c) Transition temperature
(d) Weiss temperature

[ESE-2004]

3.13 Match **List-I (Type of the material)** with **List-II (Name of the material)** and select the correct answer using the codes given below:

List-I	List-II
A. Ferroelectric	1. Rochelle salt
B. Soft magnetic	2. Alnico
C. Hard magnetic	3. Permalloy
D. Semiconductor	4. Ga As

Codes:

	A	B	C	D
(a)	3	1	2	4
(b)	1	3	2	4
(c)	3	1	4	2
(d)	1	3	4	2

[ESE-2004]

3.14 Which one of the following statements is correct? A ferrite core has lower specific eddy current loss compared to an iron core because the iron core has
(a) higher electrical resistance
(b) lower electrical resistance
(c) higher permeability
(d) lower permeability

[ESE-2004]

3.15 **Assertion (A):** Soft magnetic material is used in making electromagnets.
Reason (R): Soft magnetic materials have a high coercive field.
(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

[ESE-2004]

3.16 Consider the following statements regarding magnetic materials:
1. Relative permeability of water is 0.99999 and that of oxygen is 1.00002; hence water is diamagnetic and oxygen is paramagnetic material.
2. Ferrimagnetic material has no eddy current loss.
3. Permalloy and Alnico are two examples of hard magnetic materials.
4. The magnetisation and applied electric field in ferro-magnetic materials are related non-linearly.

Which of the statements given above are correct?
(a) 1, 2 and 3 (b) 2, 3 and 4
(c) 1, 3 and 4 (d) 1, 2 and 4

[ESE-2005]

3.17 The hysteresis loop for the material of the core of a transformer should be
(a) Short and narrow (b) Tall and narrow
(c) Short and wide (d) Tall and wide

[ESE-2005]

3.18 All magnetic materials lose their magnetic properties when
(a) Cooled to at low temperature
(b) Heated to at high temperature
(c) Kept in an aluminium box
(d) Kept in vacuum

[ESE-2005]

3.19 Which one of the following is *not* a permanent magnetic material ?
(a) Chromium steel (b) Silicon iron
(c) Cobalt steel (d) Alnico

[ESE-2005]

3.20 Above the Curie temperature, ferro-magnetic materials behave like
(a) Paramagnetic (b) Diamagnetic
(c) Anti-ferromagnetic (d) Ferrimagnetic

[ESE-2005]

3.21 Match **List-I** (Magnetic Material) with **List-II** (Order of Susceptibility) and select the correct answer using the codes given below:

List-I	List-II
A. Diamagnetic	1. $\approx 10^{+5}$
B. Paramagnetic	2. $\approx 10^{-5}$
C. Ferromagnetic	3. $\approx -10^{-5}$

Codes:

	A	B	C
(a)	1	3	2
(b)	1	2	3
(c)	3	2	1
(d)	3	1	2

[ESE-2005]

3.22 Metallic copper is a
(a) Paramagnetic substance
(b) Diamagnetic substance
(c) Ferromagnetic substance
(d) Ferrimagnetic substance

[ESE-2005]

3.23 The magnetic field required to reduce the residual magnetisation to zero is called
(a) Retentivity
(b) Coercivity
(c) Hysteresis
(d) Saturation magnetisation

[ESE-2005]

3.24 Bohr magneton is unit of
(a) Magnetic energy
(b) Permanent dipole moment due to spin
(c) Polarisability
(d) Hysteresis loss

[ESE-2005]

3.25 Magnetostriction is a phenomenon of
(a) generation of electricity in ferro-magnetic materials
(b) generation of magnetism in conductors
(c) change in permeability of ferro-magnetic materials during magnetisation
(d) change in physical dimensions of ferro-magnetic materials during magnetisation

[ESE-2005]

3.26 Which among the following magnetic materials has the highest energy-product to make it a permanent magnet?
(a) Alnico (b) Ferrite
(c) Samarium Cobalt (d) Cobalt-Iron alloy

[ESE-2006]

3.27 When the temperature of a magnetic material is raised above the Curie point, it becomes
(a) diamagnetic (b) paramagnetic
(c) ferromagnetic (d) ferrimagnetic
[ESE-2006]

3.28 Soft iron is used in the manufacture of electro-magnets because of its
(a) high saturation magnetisation only
(b) low retentivity only
(c) low coercive field only
(d) high saturation magnetisation, low reten-tivity and low coercive field
[ESE-2006]

3.29 With increase in temperature, magnetic susceptibility of a ferromagnetic material will
(a) increase
(b) decrease
(c) increase initially and then decrease
(d) remain constant
[ESE-2006]

3.30 Match **List-I** (Material) with **List-II** (Curie Temperature) and select the correct answer using the code given below the lists:

List-I	List-II
A. Fe	1. 783 K
B. $MnOFe_2O_3$	2. 523 K
C. $MgOFe_2O_3$	3. 863 K
D. $NiOFe_2O_3$	4. 1043 K

Codes:

	A	B	C	D
(a)	2	3	4	1
(b)	4	1	2	3
(c)	2	1	4	3
(d)	4	3	2	1

[ESE-2006]

3.31 Match **List-I** with **List-II** and select the correct answer using the code given below the lists:

List-I	List-II
A. No eddy current loss	1. Ferrimagnetic material
B. Small hysteresis loss	2. Soft magnetic material
C. Large hysteresis loss	3. Hard magnetic material
	4. Non-ferrous material

Codes:

	A	B	C
(a)	2	1	3
(b)	2	3	4
(c)	1	3	4
(d)	1	2	3

[ESE-2006]

3.32 In which one of the following magnetic materials, is the net magnetic moment zero?
(a) Paramagnetic (b) Ferromagnetic
(c) Ferrimagnetic (d) Anti-ferromagnetic
[ESE-2007]

3.33 Which one of the following is the correct statement?
YIG and YAG are two types of crystals used extensively in technology and are
(a) non-magnetic and magnetic, respectively
(b) magnetic and non-magnetic, respectively
(c) both magnetic
(d) both non-magnetic
[ESE-2007]

3.34 What is a material with equal, anti-parallel atomic magnetic moments, known as?
(a) Ferrimagnetic (b) Ferrite
(c) Ferromagnetic (d) Anti-ferromagnetic
[ESE-2007]

3.35 A coil wound on a magnetic core is excited from an a.c. source. The source voltage and its frequency are both doubled. What will be the eddy current loss in the core?
(a) Four times of the original value
(b) Double of the original value
(c) Same as the original value
(d) Half of the original value
[ESE-2007]

3.36 Consider the following statements:
Assertion (A): Ferrites are useful at very high frequencies.
Reason (R): Ferrites have high permeability and high resistivity.

Of these statements:
(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is not the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

[ESE-2008]

3.37 Which one of the following is the correct statement?
During the process of magnetisation of ferromagnetic material, the magnetic domains
(a) only expand
(b) rotate first and then expand
(c) expand first and then rotate
(d) neither rotate nor expand

[ESE-2008]

3.38 Match **List-I** (Material) with **List-II** (Application) and select the correct answer using the code given below the lists:

List-I	List-II
A. Silicon steel	1. High frequency transformers
B. Ferrites	2. Permanent magnets
C. Alnico	3. Current transformers
	4. Power transformers

Codes:

	A	B	C
(a)	1	2	4
(b)	4	3	2
(c)	3	4	1
(d)	4	1	2

[ESE-2008]

3.39 Materials which lack permanent magnetic dipoles are known as:
(a) Paramagnetic (b) Diamagnetic
(c) Ferromagnetic (d) Ferrimagnetic

[ESE-2008]

3.40 Why is the core of the transformer built up of laminations?
(a) To reduce eddy current loss
(b) For convenience of fabrication
(c) No specific advantage
(d) For increasing the permeability

[ESE-2008]

3.41 Magnetically hard materials do not possess which of the following characteristics?
(a) High retentivity
(b) High coercivity
(c) Strong magnetic reluctance
(d) Zero differential permeability

[ESE-2009]

3.42 On which of the following factors does hysteresis loss not depend?
(a) Magnetic field intensity
(b) Frequency of the field
(c) Volume of the material
(d) Neel temperature

[ESE-2009]

3.43 When a ferromagnetic substance is magnetized, there are small changes in dimensions. The phenomenon is called
(a) Hysteresis (b) Magnetostriction
(c) Diamagnetism (d) Dipolar relaxation

[ESE-2010]

3.44 Consider the following statements:
The coercive force can be increased by
1. Adding Cobalt because it is ferro-magnetic material.
2. Adding Gold because it is a diamagnetic material.
3. Adding Super alloy.
4. Space charge polarizing.
Which of the above statements is/are correct?
(a) 1, 2, 3 and 4 (b) 1 only
(c) 2 only (d) 1 and 3 only

[ESE-2010]

3.45 Temperature below which certain materials are anti-ferromagnetic is called
(a) Curie temperature (b) Neel temperature
(c) Wein temperature (d) Debye temperature

[ESE-2010]

3.46 Consider the following statements:
Electrets are the materials which are
1. having permanent electric moments
2. electromagnets
3. very similar to permanent magnet materials
4. similar to anti-ferroelectric materials

Which of these statements is/are correct?
(a) 2 only (b) 1 and 3 only
(c) 2 and 3 only (d) 1, 2, 3 and 4

[ESE-2010]

3.47 Consider the following statements
Magnetic susceptibility
1. depends on the nature of the magnetic material.
2. is not dependent on the relative permeability of the medium.
3. cannot be determined by measuring the force exerted on a magnetic material when placed in a magnetic field.
4. can be determined from M - H curve.

Which of these statements is/are correct?
(a) 1, 2, 3 and 4 (b) 1 only
(c) 1 and 4 only (d) 2 only

[ESE-2010]

3.48 Consider the following statements referring to the magnetization :
1. In solenoid magnetization is due to a surface current distribution.
2. Magnetization has its origin in circulating current.
3. The solenoid dipole is represented by an infinitesimal current loop.
4. The magnetization is entirely solenoidal and divergent.

Which of the above statements is/are correct?
(a) 1, 2 and 3 only (b) 2, 3 and 4 only
(c) 3 only (d) 2, 3 and 4

[ESE-2010]

3.49 **Assertion (A) :** Magnetic cores are generally used in main memory of a digital computer.
Reason (R) : Magnetic cores are slow and volatile.
(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

[ESE-2010]

3.50 **Assertion (A) :** The spins within a magnetic domain are aligned permanently below Curie temperature in a ferromagnetic material.
Reason (R) : Ferromagnetic material is magnetic only when the domains are aligned by an external field.
(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

[ESE-2010]

3.51 Heating a permanent magnet results in the loss of magnetic behaviour because
(a) The atoms start vibrating
(b) The magnetic dipoles start vibrating
(c) The magnetic dipoles start realigning
(d) The atoms start conducting

[ESE-2011]

3.52 Diamagnetic materials posses
(a) Permanent dipoles
(b) Induced dipoles
(c) Both permanent and induced dipoles
(d) No dipoles

[ESE-2011]

3.53 Paramagnetic susceptibility of a material
(a) Increase linearly with temperature
(b) Decreases linearly with temperature
(c) Increases linearly with $(1/T)$
(d) Decrease linearly with $(1/T)$

[ESE-2011]

3.54 The magnetic domains, during the process of magnetization of ferromagnetic materials,
(a) Only expand
(b) Rotate first and then expand
(c) Expand first and then rotate
(d) Neither rotate nor expand

[ESE-2011]

3.55 If the domain walls in a magnetic material can easily be moved, then the material displays
(a) High flux density
(b) High permeability
(c) Permanent magnetic behaviour
(d) High permittivity

[ESE-2011]

3.56 Magnetic field of Earth has no vertical component at
(a) Magnetic poles (b) Magnetic equator
(c) Lattitude 45° (d) Longitude 45°
[ESE-2011]

3.57 Match **List-I** with **List-II** and select the correct answer using the code given below the lists:

List-I	List-II
A. Magnetic induction	1. Bohr magneton
B. Magnetic field	2. Tesla
C. Magnetic moment	3. Henry/metre
D. Permeability	4. Ampere/metre

Codes:

	A	B	C	D
(a)	2	1	4	3
(b)	3	1	4	2
(c)	2	4	1	3
(d)	3	4	1	2

[ESE-2011]

3.58 Soft iron is used to manufacture electro-magnets because it has
(a) High retentivity (b) High coercive field
(c) Low retentivity (d) Low coercive field
[ESE-2011]

3.59 Consider the following statements with regards to soft iron:
1. It is a magnetic material.
2. It conducts electricity.
3. It is an alloy of iron and copper.
4. It is used to make permanent magnets.
Which of these statements are correct?
(a) 1 and 2 (b) 2 and 3
(c) 3 and 4 (d) 1 and 4
[ESE-2011]

3.60 A permeable substance is one
(a) which is strong magnetic
(b) which is weak magnetic
(c) which is good conductor
(d) through which magnetic lines of force can pass easily
[ESE-2011]

3.61 High-frequency transformer cores are generally made from
(a) Mu-metal (b) Mone-metal
(c) ferrites (d) cobalt
[ESE-2012]

3.62 **Statement (I):** Alnico magnet alloys have the highest energy per unit of cost or volume of any permanent magnetic material commercially available.
Statement (II): They are very hard and brittle, therefore they cannot be machined and have to be cast and finished by grinding.
(a) Both Statement (I) and Statement (II) are individually true and Statement (II) is the correct explanation of Statement (I).
(b) Both Statement (I) and Statement (II) are individually true but Statement (II) is not the correct explanation of Statement (I).
(c) Statement (I) is true but Statement (II) is false.
(d) Statement (I) is false but Statement (II) is true.
[ESE-2012]

3.63 The presence of one of the following materials, in iron or steel for use as a magnetic material, tends to reduce the hysteresis loss
(a) Carbon (b) Sulphur
(c) Phosphorus (d) Silicon
[ESE-2012]

3.64 Match **List-I** with **List-II** and select the correct answer using the code given below the lists:

List-I
A. Antiferromagnetic
B. Ferrimagnetism
C. Diamagnetic
D. Ferromagnetic

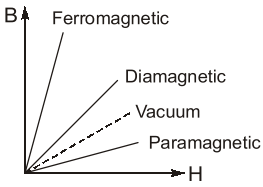
List-II
1. Permanent magnetic dipoles
2. Dipoles interact or line up in parallel
3. Neighbouring magnetic moments are aligned anti-parallel with equal magnitudes
4. Neighbouring magnetic moments are aligned anti-parallel with unequal magnitudes

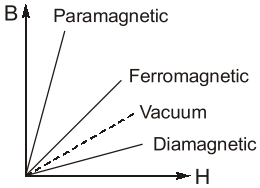
Codes:

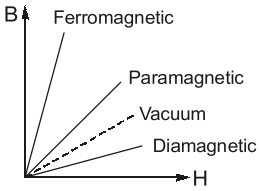
	A	B	C	D
(a)	4	3	1	2
(b)	2	3	1	4
(c)	4	1	3	2
(d)	2	1	3	4

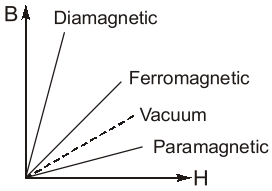
[ESE-2012]

3.65 The dependence of B (flux density) on H (magnetic field intensity) for different types of materials is

(a)


(b)


(c)


(d)


[ESE-2012]

3.66 Consider the following statements regarding magnetic materials:
1. A diamagnetic material has no permanent dipole.
2. Paramagnetic material has anti parallel orientation of equal moments with neighbouring dipoles.
3. Ferrimagnetic material has anti parallel orientation of unequal moments between neighbouring dipoles.
4. Anti ferromagnetic material has negligible interaction between neighbouring dipoles.

Which of these statements are correct?
(a) 1 and 2 (b) 3 and 4
(c) 2 and 4 (d) 1 and 3

[ESE-2013]

3.67 Consider the following statements regarding hysteresis loops of hard and soft magnetic materials:
1. Hysteresis loss of hard magnetic material will be less than that of soft material.
2. Coercivity of hard material will be greater than that of soft material.
3. Retentivity of the two materials will always be equal.

Which of these statements are correct?
(a) 1, 2 and 3 (b) 2 only
(c) 3 only (d) 1 and 3 only

[ESE-2013]

3.68 In the magnetic core the electromotive forces (emf) induced in accordance with Faraday's law of electromagnetic induction give rise to
(a) Eddy current (b) Excitation current
(c) Armature current (d) Field current

[ESE-2013]

3.69 Some magnetic materials may be classified on the basis of
1. Susceptibility
2. Saturation
3. Spin arrangement
4. Nature of hysteresis loop
5. Domain structure
6. Critical temperature above which it behaves as a paramagnetic material.

Which of these can be used to distinguish between ferri and ferromagnetic materials?
(a) 1, 3 and 4 only (b) 2, 3 and 6 only
(c) 3, 4 and 5 only (d) 1, 2, 3, 4, 5 and 6

[ESE-2013]

3.70 Magnetism is mainly due to only electron spin around their own axis in case of
(a) diamagnetic materials
(b) paramagnetic materials
(c) ferromagnetic materials
(d) paramagnetic and diamagnetic materials

[ESE-2013]

3.71 For paramagnetic materials, the relative permeability is
(a) less than unity but magnetic susceptibility is relatively small and positive
(b) greater than unity and magnetic susceptibility is relatively small but positive
(c) equal to unity and magnetic susceptibility is large but positive
(d) less than unity but magnetic susceptibility is relatively large and positive

[ESE-2013]

3.72 Permalloy and Mumetal are examples of
(a) Silicon and Iron alloys
(b) Nickel and Iron alloys
(c) Cobalt and Iron alloys
(d) Permanent magnet materials

[ESE-2013]

3.73 When a Ferromagnetic substance is magnetized, the phenomenon of 'magnetostriction' causes
(a) increase in the body temperature
(b) change in the permeability of the substance
(c) small changes in its dimensions
(d) decrease in the saturation flux-density

[ESE-2013]

3.74 The resistivity of 'Ferrites' is very much higher than that of the Ferromagnetic materials, because
(a) Ferrites are chemical compounds and the electrons in them are subject to the restraint of valence forces
(b) Ferrites have a low eddy current loss
(c) Ferrites have a non-homogeneous molecular structure
(d) Ferrites have varying flux-density inside the core

[ESE-2013]

3.75 When the temperature exceeds the transition temperature, a ferromagnetic material becomes similar to
(a) anti-ferromagnetic material
(b) diamagnetic material
(c) ferrimagnetic material
(d) paramagnetic material

[ESE-2013]

3.76 **Statement (I):** The magnetic moments of diamagnetic materials are mainly due to the orbital angular momentum of the electrons.

Statement (II): A steady current flowing in the orbit produces a magnetic field equivalent to that set up by a dipole perpendicular to the plane of orbit (Ampere's law).
(a) Both Statement (I) and Statement (II) are individually true and Statement (II) is the correct explanation of Statement (I).
(b) Both Statement (I) and Statement (II) are individually true but Statement (II) is not the correct explanation of Statement (I).
(c) Statement (I) is true but Statement (II) is false.
(d) Statement (I) is false but Statement (II) is true.

[ESE-2014]

3.77 **Statement (I):** Soft magnetic materials are not used in the construction of permanent magnets.

Statement (II): Soft magnetic materials have narrow hysteresis loop, low retentivity and low coercivity.
(a) Both Statement (I) and Statement (II) are individually true and Statement (II) is the correct explanation of Statement (I).
(b) Both Statement (I) and Statement (II) are individually true but Statement (II) is not the correct explanation of Statement (I).
(c) Statement (I) is true but Statement (II) is false.
(d) Statement (I) is false but Statement (II) is true.

[ESE-2014]

3.78 Curie law of paramagnetism
(with χ = susceptibility, B = flux density and C = *a* constant) is

(a) $\chi = CT$ (b) $\chi = \frac{CB}{T}$

(c) $\chi = \frac{CT^2}{2B}$ (d) $\chi = \frac{C}{T}$

[ESE-2014]

3.79 If the magnetic susceptibility of a specimen is small and positive, the specimen is
(a) diamagnetic (b) paramagnetic
(c) ferromagnetic (d) non-magnetic

[ESE-2014]

3.80 Manganese ferrite is a 1 : 1 mixture of
(a) Manganese nitride and iron oxide
(b) Manganese oxide and iron oxide
(c) Manganese nitride and iron sulphide
(d) Manganese oxide and iron sulphide

[ESE-2014]

3.81 When a ferromagnetic substance is magnetized, small changes in dimensions occur. Such a phenomenon is known as

(a) Magnetic hysteresis
(b) Magnetic expansion
(c) Magnetostriction
(d) Magneto-colorisation

[ESE-2014]

3.82 In ferromagnetic, antiferromagnetic and ferrimagnetic materials, the atomic thermal motions counteract the coupling forces between the adjacent atomic dipole moments, thereby causing
(a) some dipole misalignment regardless of whether an external field is present
(b) increase in dipole alignment regardless of whether an external field is present
(c) no effect on dipole alignment
(d) atoms tend to de-randomize the direction of moments

[ESE-2014]

3.83 For high-speed reading and storing of information in a computer, the material used is
(a) ferrite
(b) piezoelectric
(c) pyroelectric
(d) ferromagnetic above 768 °C

[ESE-2015]

3.84 The temperature above which an anti-ferromagnetic material becomes paramagnetic is called
(a) peak temperature (b) Neel temperature
(c) critical temperature (d) Weiss temperature

[ESE-2015]

3.85 Magnetic materials which may be readily magnetized in either direction are
(a) soft magnetic materials
(b) hard magnetic materials
(c) high eddy current loss materials
(d) high hysteresis loss materials

[ESE-2015]

3.86 Consider the following statements regarding a ferromagnetic material :
1. Below the ferromagnetic Curie temperature, the ferromagnetic materials exhibit hysteresis effect.
2. The coercive force is the field required to reduce the flux density to zero.

Which of the above statements is /are correct?
(a) Both 1 and 2 (b) Neither 1 nor 2
(c) 1 only (d) 2 only

[ESE-2015]

3.87 Permeance is inversely related to
(a) resistance (b) conductance
(c) reluctance (d) capacitance

[ESE-2016]

3.88 Consider the following statements regarding an ideal core material:
1. It has very high permeability.
2. It loses all its magnetism when there is no current flow.
3. It does not saturate easily.

Which of the above statements are correct?
(a) 1 and 2 only (b) 1 and 3 only
(c) 2 and 3 only (d) 1, 2 and 3

[ESE-2016]

3.89 The relative permeability of a medium is equal to (with M = magnetization of the medium and H = magnetic field strength)

(a) $1+\frac{M}{H}$ (b) $1-\frac{M}{H}$

(c) $1+\sqrt{\frac{M}{H}}$ (d) $1-\sqrt{\frac{M}{H}}$

[ESE-2016]

3.90 Permanent magnet loses the magnetic behaviour when heated because of
1. atomic vibration
2. dipole vibration
3. realignment of dipoles

Which of the above are correct?
(a) 1 and 2 only (b) 1 and 3 only
(c) 1, 2 and 3 (d) 2 and 3 only

[ESE-2016]

3.91 The magnetic field required to reduce the residual magnetization to zero is called
(a) retentivity (b) coercivity
(c) hysteresis (d) saturation

[ESE-2016]

3.92 Consider the following statements:
1. Both ferromagnetic and ferrimagnetic materials have domain structures; each domain has randomly oriented magnetic moments when no external field is applied.

Answers Magnetic Properties of Materials

3.1	(a)	3.2	(b)	3.3	(c)	3.4	(d)	3.5	(c)	3.6	(a)	3.7	(b)	3.8	(b)	3.9	(c)
3.10	(d)	3.11	(d)	3.12	(b)	3.13	(b)	3.14	(b)	3.15	(c)	3.16	(d)	3.17	(b)	3.18	(b)
3.19	(b)	3.20	(a)	3.21	(c)	3.22	(b)	3.23	(b)	3.24	(b)	3.25	(d)	3.26	(a)	3.27	(b)
3.28	(c)	3.29	(b)	3.30	(b)	3.31	(d)	3.32	(d)	3.33	(b)	3.34	(d)	3.35	(a)	3.36	(a)
3.37	(c)	3.38	(d)	3.39	(b)	3.40	(a)	3.41	(d)	3.42	(d)	3.43	(b)	3.44	(b)	3.45	(b)
3.46	(c)	3.47	(c)	3.48	(b)	3.49	(c)	3.50	(c)	3.51	(b, c)	3.52	(b)	3.53	(c)	3.54	(c)
3.55	(b)	3.56	(b)	3.57	(c)	3.58	(d)	3.59	(a)	3.60	(d)	3.61	(c)	3.62	(b)	3.63	(d)
3.64	(*)	3.65	(c)	3.66	(d)	3.67	(b)	3.68	(a)	3.69	(a)	3.70	(c)	3.71	(b)	3.72	(b)
3.73	(c)	3.74	(a)	3.75	(d)	3.76	(a)	3.77	(a)	3.78	(d)	3.79	(b)	3.80	(b)	3.81	(c)
3.82	(b)	3.83	(a)	3.84	(b)	3.85	(a)	3.86	(a)	3.87	(c)	3.88	(d)	3.89	(a)	3.90	(c)
3.91	(b)	3.92	(d)	3.93	(b)	3.94	(d)	3.95	(c)	3.96	(a)	3.97	(a)	3.98	(b)	3.99	(c)
3.100	(b)	3.101	(c)	3.102	(a)	3.103	(b)	3.104	(b)	3.105	(d)	3.106	(c)	3.107	(a)	3.108	(a)
3.109	(d)	3.110	(b)	3.111	(c)	3.112	(c)	3.113	(b)	3.114	(a)	3.115	(a)	3.116	(b)	3.117	(b)
3.118	(c)	3.119	(a)	3.120	(c)	3.121	(b)	3.122	(a)	3.123	(c)	3.124	(a)	3.125	(b)		

Explanations Magnetic Properties of Materials

3.1 (a)

Higher the exchange interaction energy, higher will be area under B-H curve i.e. high saturation magnetization (because value of B at saturation will be very high).

3.2 (b)

Copper → Cu is a diamagnetic material
Iron → Ferromagnetic material
Ferrite → Ferrimagnetic material
Na → Is not a antiferromagnetic material actually it is not a magnetic material but NaCl is a diamagnetic material.

3.3 (c)

Ferromagnetic behaviour is shown by those transition metals where the ratio of atomic diameter to 3d-orbital diameter is in between 1.5 to 2.

3.4 (d)

Chemical formula of simple ferrites may be written as

$$Me^{2+}Fe_2^{3+}O_4^{2-} \quad \text{i.e. } AB_2O_4$$

where Me^{2+} → represents a variety of divalent metallic ions such as

$Fe^{2+}, CO^{2+}, Mn^{2+}, Zn^{2+}, Cd^{2+}, Mg^{2+}$ etc. formula may be written as mixture of MeO and Fe_2O_3.

3.5 (c)

Ni – Zn ferrite → used in audio and TV Transformers
Co – Sm alloy → used as permanent magnets (because it exhibits the property of high coercive force and high resistivity).
Yttrium Iron Garnet → used as microwave isolator (It is a magnetic material).
Mg – Zn ferrite → used as memory cores.

3.6 (a)

Ferroelectric material → e.g. KH_2PO_4
Piezoelectric material → $BaTiO_3$, Ceramic
Soft magnetic material → e.g. permalloy
Hard magnetic material → e.g. Tungsten steel.

3.7 (b)

The dc resistivity of ferrites is many orders of ten higher than that of iron; consequently it prevents penetration of magnetic flux into the

material. Further, coercive force (H_c) for a high stability permanent magnet may be as high as 10^6 ampere–m^{-1} as compared to ferrites having as low as 1 ampere–m^{-1}.

3.8 (b)

Electrical resistivity has to be high for ferrites, 4% Si is added to Fe which is ferromagnetic material. Further upon adding 4% Si, coercive force and B_{sat} both decreases. Permeability is increased by grain oriented silicon steel.

3.9 (c)

χ_m is negative for diamagnetic material and as long as the electronic structure of the material is independent of temperature, the diamagnetic susceptibility is also essentially independent of temperature.

3.10 (d)

Silicon steel → used in power transformer.
Ferrite → used in high frequency transformer.
Alnico → It is hard ferrite used as permanent magnet.

3.11 (d)

$$\text{Larmour frequency} = \frac{eB}{2m}$$

$m \rightarrow$ mass of e^-

$$\text{Bohr magnetron} = \frac{eh}{4\pi m}$$

m = mass of e^-,
h = Planck's constant

Magnetic induction,

$B = \mu_0(H + M)$
M = magnetization.

Curie-Weiss law, $\chi = \dfrac{C}{T - \theta}$

3.12 (b)

The Neel temperature plays a similar role in antiferromagnetic materials as does the curie temperature in ferromagnetic materials.

3.13 (b)

Ferroelectric material → e.g.. Rochelle salt
Soft magnetic material → e.g. Permalloy
Hard magnetic material → e.g.. Alnico
Semiconductor → GaAs (direct band gap)

3.14 (b)

The dc resistivity of ferrites is many orders of ten higher than that of iron, consequently the eddy current problem preventing penetration of magnetic flux into the material is much less severe in ferrites than in iron.

3.15 (c)

Hard magnetic materials have a high coercive field.

3.16 (d)

Permeability of water $\mu_{rw} = 0.99999 < 1$
Permeability of oxygen $\mu_{ro} = 1.00002 > 1$
so, water is diamagnetic material .
and oxygen is paramagnetic material. So 1 is right. Permalloy is soft alnico is hard so statement (3) is wrong.

3.17 (b)

It should have high $B_{saturation}$ and low coercive field H_C.

3.18 (b)

$$\chi(\text{susceptibility}) \propto \frac{1}{\text{Temperature}}$$

as T increases, χ decreases, so these losses their magnetic properties.

3.19 (b)

4% Si - Fe is a soft magnetic material having coercive field $H_C = 40$ amp-m^{-1}.

3.20 (a)

Above curie temperature ferromagnetic material loses their property of ferro-magnetism as χ_m magnetic susceptibility decreases and becomes paramagnetic material. ($\chi_m \propto 1/T$).

3.21 (c)

Diamagnetic material → Magnetic susceptibility is –ve and small $\simeq -10^{-5}$
Paramagnetic material → +ve and small $\simeq 10^{-5}$
Ferromagnetic material → +ve and large $\approx 10^5$

3.22 (b)

Metallic copper is diamagnetic substance having negative value of magnetic susceptibility.

3.23 (b)

Magnetic field required (applied) in reverse direction to reduce residual magnetization (spontaneous magnetization) is called coercive magnetic field and this phenomenon is called coercivity.

3.24 (b)

Bohr magnetron = $\dfrac{eh}{4\pi m}$ is unit of permanent dipole moment due to spin of e^{-s} in orbital.

3.25 (d)

Magnetostriction is phenomenon of change in dimension of ferromagnetic material due to magnetization Reverse of this effect is called as villari effect.

3.26 (a)

In magnetic materials Alnico having maximum energy product used for making permanent magnet.

3.27 (b)

In the region above the ferromagnetic curie temperature, the behaviour of a ferromagnetic material is some what similar to that of a paramagnetic material. Below the ferromagnetic curie temperature, ferromagnetic materials exhibit the well-known hysteresis in the *B* versus *H* curves.

3.28 (c)

Magnetic materials which have low coercive field are known as soft materials. Permanent magnets are made of hard materials which have a broad hysteresis loop (large coercive force), so that they are not subject to self-demagnetisation.

3.29 (b)

$$\chi = \frac{C}{(T-\theta)}$$

3.30 (b)

	Actual values
$Fe \rightarrow 1043$ K	1043 K
$MnOFe_2O_3 \rightarrow 863$ K	573 K
$MgOFe_2O_3 \rightarrow 523$ K	713 K
$NiOFe_2O_3 \rightarrow 783$ K	863 K

3.31 (d)

Ferrimagnetic material such as ferrites do not have eddy current loss.

3.32 (d)

In Antiferromagnetic material the dipole moment of adjacent atoms are align in opposite direction and equal in magnitude so net magnetization is zero.

3.33 (b)

In YIG, I represent Iron (Yttrium Iron Garnet)
In YAG, A represent Aluminium (Yttrium Aluminium garnet).
I → Iron is magnetic
Al → Non magnetic

3.34 (d)

Dipole moment for antiferromagnetic

↑↓↑↓↑↓↑↓↑↓↑↓ equal and antiparallel.

3.35 (a)

$$P_e = K_e B^2 f^2$$

$$B = \frac{V}{f} = \text{const. if both doubled}$$

So, $P_e = K_e V^2$

So, $P_e \propto V^2$

for $V' = 2\,V$

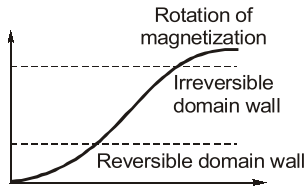
$\therefore \quad P_e' = 4\,P_e$

3.36 (a)

High permeability and resistivity are main cause of application at high frequency for ferrites.

3.37 (c)

On application of field firstly domain wall expand and then rotates.



3.38 (d)

Silicon steel → Used in power transformer.
Ferrites → Used in high frequency transformer.
Alnico → Permanent magnets.

3.39 (b)

Diamagnetic material does not have permanent dipole moment in the absence of magnetic field.
Paramagnetic material: It has permanent dipole moment but all atom have dipole moment in random direction so net dipole moment is zero in absence of magnetic field.

3.40 (a)

Lamination is provided to reduce eddy current losses.

$$P_e = k_e B^2 f^2 t^2$$

3.41 (d)

Magnetically hard materials possess high retentivity and high coercivity.

3.42 (d)

Neel temperature is a transition temperature above which Antiferromagnetic material becomes

paramagnetic, It has no deal with hysteresis loss.

$$P_h \propto K_h f B^n V$$

3.43 (b)

There are small changes in dimensions when ferromagnetic substance magnetized this phenomena is called magnetostriction.

3.44 (b)

Coercive force can be increased by adding hard magnetic material like cobalt.

3.45 (b)

Below Neel temperature magnetic material exhibit anti-ferromagnetic and above neel temperature behaves as paramagnetic.

3.46 (c)

Electrets are electrical analogy of electromagnets very similar to permanent magnet materials.

3.47 (c)

Magnetic susceptibility depends on

1. Nature of material
2. Permeability of medium

3.49 (c)

Magnetic core made of ferromagnetic metal or ferrimagnetic which is non-volatile since used for recording heads.

3.50 (c)

Ferromagnetic material is also magnetic if no external field applied.

3.51 (b, c)

Heating causes vibration of magnetic dipoles, so their alignment in one particular direction is lesser so loss of magnetic behaviour.

3.52 (b)

Diamagnetic materials possess only induced dipole, in absence of magnetic field there is no dipoles and dipole moment is zero.

3.53 (c)

For paramagnetic material,

Magnetic susceptibility

$$\chi_m = \frac{C}{T - \theta}$$

θ is curie temperature

$$\chi_m \propto \frac{1}{T}$$

so increases with $1/T$

3.54 (c)

During process of magnetization of ferromagnetic materials magnetic domains first expand and then rotate.

3.55 (b)

Domain walls in magnetic material can be easily moved in case of ferromagnetic materials which has high value of permeability.

3.56 (b)

At magnetic equator, magnetic field of Earth has only horizontal component (tangential component) and no vertical component (normal component) as earth is a conductor.

3.57 (c)

Magnetic field H has unit A/m. $B - 4$.

Magnetic field $\rightarrow$ Bohr magnetron, $C - 1$.

Magnetic induction $\rightarrow$ Tesla or Weber/m^2 $A - 2$.

Permeability $\rightarrow$ H/m $\rightarrow$ $D - 3$.

3.58 (d)

Soft iron is used to manufacture electromagnets because it has low cohesive field so they can response easily to alternating field.

3.59 (a)

Soft iron is a magnetic material. It is used to make electromagnets not permanent magnets so 4 is wrong.

Statement 1 is right, option (a) is correct.

3.60 (d)

A permeable substance means having a high value of permeability means through which magnetic lines of force can pass easily.

3.61 (c)

Ferrites with useful magnetic properties have d.c. resistivity of many orders of ten higher than in iron, and are used for frequencies upto microwave in transformer cores.