DETAILED SOLUTIONS

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ESE 2026 : Prelims Exam | CLASSROOM TEST SERIES

GS & ENGINEERING APTITUDE

Test 5

Section A : General Principles of Design, Drawing, Importance of Safety [All Topics]

Section B : Basics of Energy and Environment [All Topics]

Section C : Basics of Material Science [All Topics]

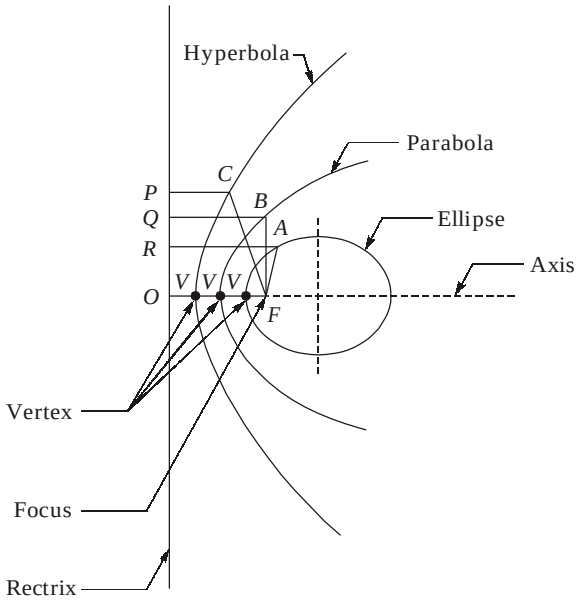
Answer Key

1.	(c)	11.	(d)	21.	(b)	31.	(c)	41.	(a)
2.	(c)	12.	(d)	22.	(d)	32.	(b)	42.	(b)
3.	(c)	13.	(c)	23.	(b)	33.	(b)	43.	(b)
4.	(d)	14.	(d)	24.	(c)	34.	(d)	45.	(c)
5.	(c)	15.	(d)	25.	(c)	35.	(d)	44.	(c)
6.	(d)	16.	(d)	26.	(c)	36.	(d)	46.	(b)
7.	(b)	17.	(d)	27.	(c)	37.	(b)	47.	(d)
8.	(b)	18.	(a)	28.	(c)	38.	(c)	48.	(b)
9.	(a)	19.	(d)	29.	(d)	39.	(b)	49.	(a)
10.	(b)	20.	(d)	30.	(b)	40.	(c)	50.	(b)

Q.15 : Marks to all

Section A : General Principles of Design, Drawing, Importance of Safety

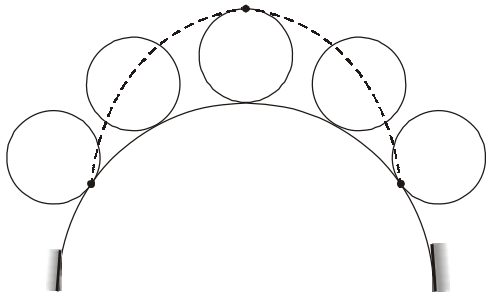
1. (c)



Eccentricity (e) is the ratio of distance of a point on curve from focus to that of directrix.

2. (c)

Curve which is formed by a point on the circumference of a disc which rolls without slipping on a convex side of a fixed circular arc is known as Epicycloid.



3. (c)

Ellipse is a closed curve with the following unique properties:

- Any point on the ellipse moves in such a way that the sum of its distance from the two foci is always a constant and equal to the length of the major axis.
- As the ellipse is symmetrical about the major and minor axis, the distance of the end point of the minor axis from the focus is equal to the length of semi-major axis.
- The construction methods for ellipse make use of these properties. Some of the common methods are pin and thread method, arc of circle, and concentric circles methods.

4. (d)

$$\text{Drawing Size} = 1.5\text{ cm} = 15000\ \mu\text{m}$$

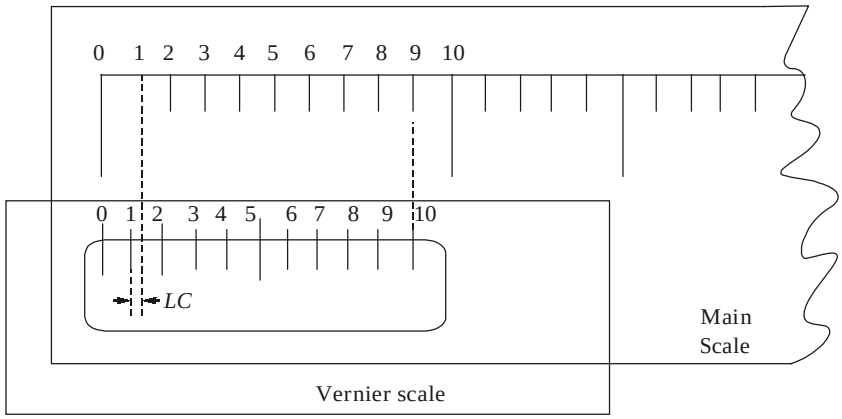
$$\text{Actual size} = 2\ \mu\text{m}$$

$$\text{Representative fraction, RF} = \frac{\text{Drawing size}}{\text{Actual size}}$$

$$\text{RF} = \frac{1500\mu\text{m}}{2\mu\text{m}} = 7500$$

5. (c)

$$\text{Vernier scale (LC)} = 1\text{ MSD} - 1\text{ VSD}$$



6. (d)

Plain and diagonal scales: A plain scale is used to measure only two consecutive units in the same system of measurement or will read up to a single decimal place only, whereas a diagonal scale is used to represent three consecutive units or up to two decimal accuracies.

7. (b)

- The front view and the top view are laid from the reference line (intersecting line of VP and HP) depending on the distances of the object from these planes. The front view is placed above the reference line and the top view directly below it. The side views on the right and left sides are arranged by the sides of the front view, with the vertical reference line in between. The right-hand side view of the object is placed on to the left of the front view, whereas the left-hand side view of the object is placed to the right of the front view. Positioning of the object and the placement scheme thus discussed is called as the first-angle projection.
- Positioning of the object behind the vertical plane and below the horizontal plane results in the interchange of views in the layout and such reference scheme is called third-angle projection.

8. (b)

Projectors are parallel to each other and also perpendicular to the plane, the projection formed is known as orthographic projection.

9. (a)

The projections are obtained by independently considering the two inclinations and superimposing the individual projections suitably. This method is known as rotating line method.

10. (b)

Traces of a Straight Line : The trace of a line is a point at which the line intersects a reference plane or meets it imaginarily when extended from either of its ends.

11. (d)

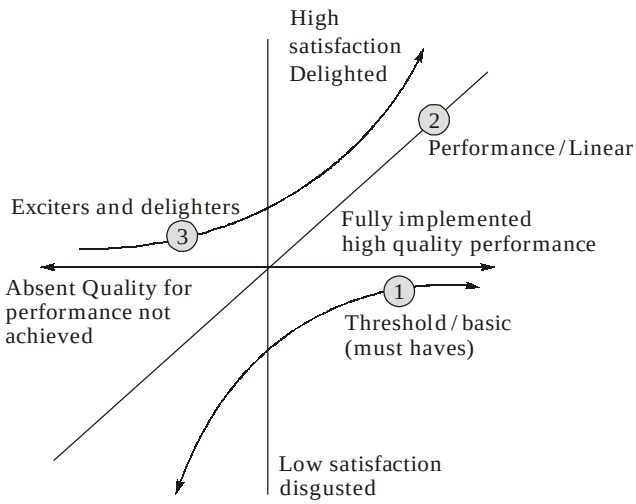
Steps in engineering design process:

The Steps Used for Solving Design Problems are:

1. Define the Problem
2. Gather Pertinent Information
3. Generate Multiple Solutions
4. Analyze and Select a Solution
5. Test and Implement the Solution

12. (d)

A Kano diagram is a good tool to visually partition customer requirements into categories that will allow for their prioritization. Kano recognized that there are four levels of customer requirements:



1. Expecters: Basic attributes that the customer expects.
2. Spokens: Specific features that customers say they want.
3. Unspokens: Important attributes the customer does not talk about.
4. Exciters: Features that make the product unique and distinguish it from the competition. Note that the absence of an exciter will not make customers unhappy, since they do not know that is missing.

13. (c)

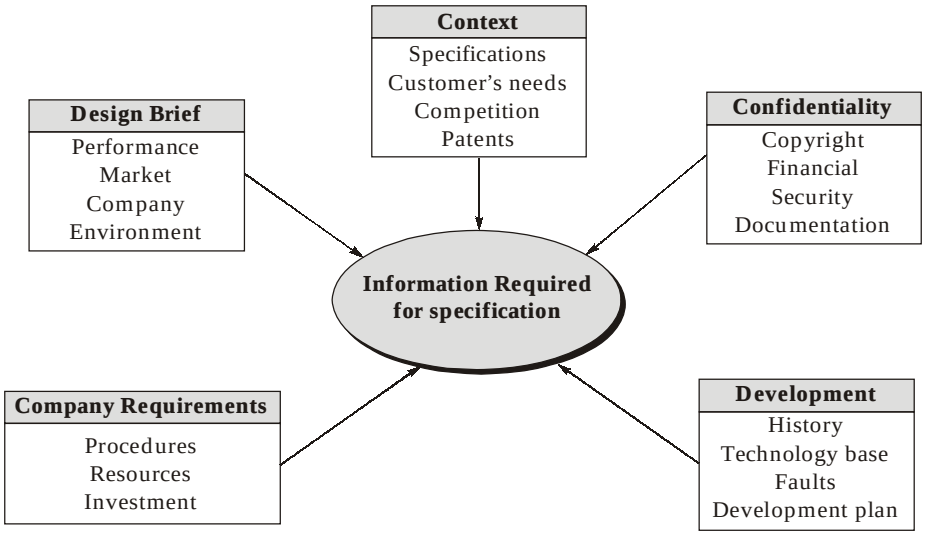
Benchmarking is a process for measuring a company's operations against the best practices of companies both inside and outside of their industry.

Benchmarking operates most effectively on a quid pro quo basis as an exchange of information between companies that are not direct competitors but can learn from each other's business operations. Other sources for discovering best practices include business partners (e.g., a major supplier to your company), business in the same supply chain (e.g., automobile manufacturing suppliers), companies in collaborative and cooperative groups, or industry consultants. Sometimes trade or professional associations can facilitate benchmarking exchanges. More often, it requires good contracts and offering information from your own company that may seem useful to the companies you benchmark.

14. (d)

Information Gathering for a particular PDS

The information required falls mainly under the following broad headings:



15. (d)

Concept Generation Methods:

Brainstorming guidelines include:

- Focus on quantity
- Withhold criticism
- Record all ideas
- Combine and improve ideas
- Stay focused on topic

16. (d)

Particularly intriguing source of direct analogies is those that are inspired by biological systems. This subject is called Biomimetics.

17. (d)

Barriers of creative thinking:

1. Perceptual blocks: Stereotyping, Information overload, Fixation
2. Emotional blocks: Fear of risk taking, unease with chaos
3. Cultural blocks
4. Intellectual blocks: Memory block, incased information
5. Environmental blocks: Physical environment, criticism

18. (a)

Risk : It is the likelihood of a substance, activity or process to cause harm. A risk can be reduced and its hazard controlled by good management.

Risk calculation : The risk imposed by some particular hazard can be taken as increasing:

1. with the likelihood that the hazardous event will actually occur,
2. with exposure to that event, and
3. with possible consequences of that event.

For risk calculations, numerical values are assigned to each of these three factors. Then an overall risk score is computed as the product of these three separate factors. The numerical values, although arbitrary chosen, are self-consistent and together they provide a realistic but relative score for the overall risk.

$$\text{Risk score, } R = C \times E \times P$$

where, C is consequence rating, E is exposure value, P is probability value.

19. (d)

Near miss: This is any incident or event that did not happen, but could have resulted in an accident.

20. (d)

Similarities Between a Safety Inspection and Safety Audit

- Broad goals: Both strive for a safer workplace that complies with all regulations and standards.
- Safety checklists: Both may use a safety checklist that includes relevant OSHA standards, best practices, and other recommended precautions.
- OSHA requirements: OSHA does not require safety audits or inspections, but the agency views both as components of an effective safety plan.

21. (b)

A-3, B-4, C-2, D-1

22. (d)

Accident causation theories

Over the years several theories of accident causation have been evolved that attempt to explain why accidents occur, but so far none has been universally accepted. Researchers from different fields of science and engineering have been trying to develop a theory of accident causation which will help to identify, isolate and ultimately remove the factors that contribute to or cause accidents. Various accident causation theories are as follows:

1. The Domino Theory
2. The Human Factors Theory
3. The Epidemiological Theory
4. The Systems Theory
5. The Combination Theory

23. (b)

Job Hazard Analysis

One way to increase the knowledge of hazards in the workplace is to conduct a job hazard analysis on individual tasks. A job hazard analysis (JHA) is a technique that focuses on job tasks as a way to identify hazards before they occur. It focuses on the relationship between the worker, the task, the tools, and the work environment. In a JHA, each basic step of the job is examined to identify potential hazards and to determine the safest way to do the job. Other terms used to describe this procedure are Job Safety Analysis (JSA) and job hazard breakdown.

A job hazard analysis is one component of the larger commitment of a safety and health management system. Supervisors can use the findings of a job hazard analysis to eliminate and prevent hazards in their workplaces. This is likely to result in fewer worker injuries and illnesses, safer, more effective work methods, reduced workers compensation costs, and increased worker productivity. The analysis also can be a valuable tool for training new employees in the steps required to perform their jobs safely.

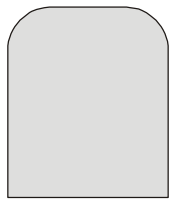
- Selecting the job to be analyzed.
- Breaking the job down into a sequence of steps.
- Identifying potential hazards.
- Determining preventive measures to overcome these hazards.

24. (c)

Symbols are used to represent various events and describe relationships:

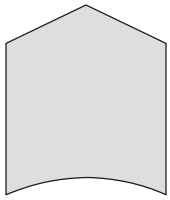
AND Gate represents a condition in which all the events shown below the gate (input gate) must be present for the event shown above the gate (output event) to occur. This means the output event will occur only if all of the input events exist simultaneously.

AND Gate



OR gate represents a situation in which any of the events shown below the gate (input gate) will lead to the event shown above the gate (output event). The event will occur if only one or any combination of the input events exists.

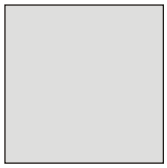
OR Gate



There are five types of event symbols :

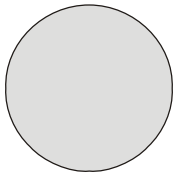
The rectangle is the main building block for the analytical tree. It represents the negative event.

Rectangle



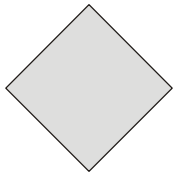
A circle represents a base event in the tree.

Circle



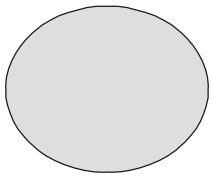
The diamond identifies the undeveloped terminal event.

Diamond



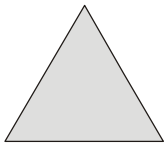
An oval symbol represents a special situation that can only happen if certain circumstances occur.

Oval



The triangle signifies a transfer of a fault tree branch to another location within the tree.

Triangle



25. (c)

When the vertical solids are prismatic or cylindrical, the curves of intersection appear only in the front view.

When the vertical solid is pyramidal or conical, the intersection curves are obtained in the top and in the front views.

Section B : Basics of Energy & Environment

26. (c)

- CITES is an international agreement that stands for the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). It was drafted as a result of a resolution adopted in 1963 by the members of the International Union for Conservation of Nature (IUCN). It entered into force in July 1975.
- CITES is an international agreement to which States and regional economic integration organizations adhere voluntarily.
- The CITES works by subjecting international trade in specimens of selected species to certain controls. All import, export, re-export and introduction from the sea of species covered by the Convention has to be authorized through a licensing system.

27. (c)

- Climate and Clean Air Coalition unites governments is committed to improving air quality and protecting the climate in next few decades by reducing short-lived climate pollutants (SLCP) across sectors.
- Carbon dioxide is not one of the eight pollutants measured under the National Air Quality Index.

  The measurement are based on following eight pollutants:

  1. Particulate Matter 2.5
  2. Ozone
  3. Carbon monoxide
  4. Ammonia
  5. Lead
  6. Nitrogen oxide
  7. Sulpher dioxide
  8. PM 10

28. (c)

- The United Nations Convention to Combat Desertification (UNCCD) is the sole legally binding international agreement linking environment and development to sustainable land management.
- The Convention addresses specifically the arid, semi-arid and dry sub-humid areas, known as the drylands, where some of the most vulnerable ecosystems and peoples can be found.
- UNCCD was adopted in Paris on 17 June 1994 and entered into force on 26 December 1996.

29. (d)

- The Intergovernmental Panel on Climate Change (IPCC) is the international body for assessing the science related to climate change.
- The IPCC was set up in 1988 by the World Meteorological Organization (WMO) and United Nations Environment Programme (UNEP) to provide policymakers with regular assessments of the scientific basis of climate change, its impacts and future risks, and options for adaptation and mitigation.

- IPCC assessments provide a scientific basis for governments at all levels to develop climate-related policies, and they underlie negotiations at the UN Climate Conference – the United Nations Framework Convention on Climate Change (UNFCCC).
- The participation in the IPCC is open to all member countries of the WMO and United Nations.

30. (b)

- **PARIVESH** stands for Pro-Active and Responsive facilitation by Interactive, Virtuous and Environmental Single-window Hub.
- It is a Single-Window Integrated Environmental Management System, developed in pursuance of the spirit of 'Digital India'.
- It is a web based, role based workflow application which has been developed for online submission and monitoring of the proposals submitted by the proponents for seeking Environment, Forest, Wildlife and CRZ Clearances from Central, State and district level authorities.

31. (c)

- The Stockholm Convention is a global treaty to protect human health and the environment from persistent organic pollutants (POPs). POPs are chemicals that remain intact in the environment for long periods, become widely distributed geographically, accumulate in the fatty tissue of living organisms and are toxic to humans and wildlife. POPs circulate globally and can cause damage wherever they travel. In implementing the Convention, Governments will take measures to eliminate or reduce the release of POPs into the environment. Over 152 countries ratified the Convention and it entered into force, on 17 May 2004.
- The Global Environmental Facility (GEF) is the designated interim financial mechanism for the Stockholm Convention.
- United Nations Industrial Development Organization is also responsible for supporting developing countries and countries with economies in transition to implement the Stockholm Convention.

32. (b)

- The NGT was established on October 18, 2010 under the National Green Tribunal Act 2010, passed by the Central Government.
- Powers
- The NGT has the power to hear all civil cases relating to environmental issues and questions that are linked to the implementation of laws listed in Schedule I of the NGT Act. These include the following:
  - The Water (Prevention and Control of Pollution) Act, 1974;
  - The Water (Prevention and Control of Pollution) Cess Act, 1977;
  - The Forest (Conservation) Act, 1980;
  - The Air (Prevention and Control of Pollution) Act, 1981;
  - The Environment (Protection) Act, 1986;
  - The Public Liability Insurance Act, 1991;
  - The Biological Diversity Act, 2002.

- This means that any violations pertaining only to these laws, or any order/decision taken by the Government under these laws can be challenged before the NGT.

- Importantly, the NGT has not been vested with powers to hear any matter relating to the Wildlife (Protection) Act, 1972, the Indian Forest Act, 1927 and various laws enacted by States relating to forests, tree preservation etc.

33. (b)

- The Bonn Challenge is a global goal to bring 150 million hectares of degraded and deforested landscapes into restoration by 2020 and 350 million hectares by 2030.
- Launched by the Government of Germany and IUCN in 2011, the challenge has already surpassed the 150-million-hectare milestone for pledges in 2017.
- India joined the Bonn Challenge in 2015 with a pledge to restore 21 million hectares of degraded and deforested land.
- This was raised to a target of 26 million hectares by 2030 during the United Nations Convention on Combating Desertification (UNCCD) Conference, held in Delhi in September 2019.
- **Bonn Convention**
  - Its objective is to protect the migratory species of wild animals and their habitats, and it works under the aegis of UNEP.
  - It is also known as the Convention on Conservation of Migratory Species of Wild Animals (CMS).
  - India has been a party to the Bonn Convention since 1983.

34. (d)

- Trophic cascades are powerful indirect interactions that can control entire ecosystems. They occur when predators limit the density and/or behavior of their prey and thereby enhance survival of the next lower trophic level.
- Predators eat prey. By so doing, predators can impact both prey abundance and behavior (e.g., prey get scared when predators are around and hide or move away).
- When the impact of a predator on its prey's ecology trickles down on more feeding level to affect the density and/or behavior of the prey's prey, ecologists term this interaction a feeding, or trophic cascade.

35. (d)

The vulnerability of a species to extinction depends on a wide variety of factors, some of which are:

- Species with narrow geographical ranges. Such locally endemic species are highly susceptible to extinction.
- Seasonal migratory species are depended on two or more distinct habitat types, and are unable to survive if either habitat is destroyed.
- Species low in genetic variability: Adapting to new environments and changing conditions depend on the availability of genetic diversity.
- Species with small population sizes.
- Species that need large home range, like the Bengal Tiger. Usually, large sized animals require larger ranges.

36. (d)

37. (b)

38. (c)
Wind energy has low energy density.

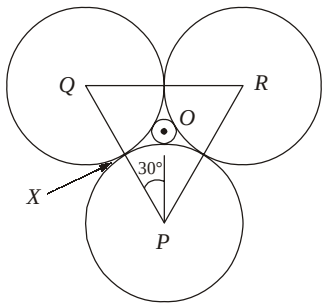
Section C : Basics of Material Science

39. (b)
The dependence of physical properties of specimen on the crystallographic direction is termed as anisotropy, and it is associated with the variance of atomic or ionic spacing with crystallographic direction. Substances in which measured properties the independent of the direction of measurement are isotropic. The extent and magnitude of anisotropic effects in crystalline materials are functions of the symmetry of the crystal structure. The degree of anisotropy increases with decreasing structural symmetry - triclinic structures normally are highly anisotropic. Even though each grain may be anisotropic, a specimen composed of the grain aggregate behaves isotropically for many polycrystalline materials.

40. (c)
Planar density (PD) is defined as the number of atoms per unit area that are centered on a particular crystallographic plane, or

$$PD = \frac{\text{Number of atoms centered on a plane}}{\text{Area of plane}}$$

41. (a)
For coordination number of 3, the small cation is surrounded by three anions to form an equilateral triangle as shown below.



Considering the radius of cation as R_C and radius of anion as R_A, we get

$$PX = R_A$$
$$PO = R_A + R_C$$
$$\frac{PX}{PO} = \frac{R_A}{R_A + R_C} = \cos 30°$$
$$\Rightarrow \quad \frac{R_C}{R_A} = \frac{1 - \cos 30°}{\cos 30°} = 0.155$$

42. (b)

The rock salt crystal structure is found in the mineral halite (rock salt), which is naturally occurring sodium chloride (NaCl). This structure is also found in other compounds with a 1 : 1 ratio of cations to anions, such as some alkali halides (like KCl) and metal oxides (like MgO).

Structure Name	**Examples**
Rock salt	NaCl, MgO, FeO
Sphalerite	ZnS, SiC
Fluorite	CaF_2, UO_2, ThO_2
Perovskite	$BaTiO_3$, Sr Sn O_3
Spinal	$MgAl_2O_4$, $FeAl_2O_4$

43. (b)

Coordination Number	**Rc / Ra**
2	< 0.155
3	0.155 - 0.225
4	0.225 - 0.414
6	0.414 - 0.732
8	0.732 - 1.0
12	1.0

For a radius ratio equal to unity, the coordination number is 12.

44. (c)

We know that,

$$\%\text{Crystallinity} = \frac{\rho_c(\rho_s - \rho_a)}{\rho_s(\rho_c - \rho_a)} \times 100$$

Given, $\rho_c = 1000\ \text{kg/m}^3$; $\rho_s = 925\ \text{kg/m}^3$; $\rho_a = 860\ \text{kg/m}^3$

$$\therefore \quad \%\text{Crystallinity} = \frac{1000(925-860)}{925(1000-860)} \times 100$$

$$= 50.19\% \simeq 50.2\%$$

45. (c)

Gallium arsenide (GaAs) has a band gap of about 1.43 eV, which corresponds to

$$\lambda = \frac{hc}{E} = \frac{6.626 \times 10^{-34} \times 3 \times 10^8}{1.43 \times 1.6 \times 10^{-19}} \simeq 870\ \text{nm}$$

i.e. near-infrared region of electromagnetic spectrum.

while Gallium phosphate (GaP) has a band gap of about 2.3 eV, which corresponds to

$$\lambda = \frac{hc}{E} = \frac{6.626 \times 10^{-34} \times 3 \times 10^8}{2.3 \times 1.6 \times 10^{-19}} \simeq 540\ \text{nm}$$

i.e. green portion of the visible spectrum.

46. (b)

The Meissner effect is the phenomenon in which a superconductor expels all magnetic field lines from its interior when cooled below the critical temperature T_C.

47. (d)

Materials for use as permanent magnets should have the following characteristics:

(i) High permeability to allow magnetic flux to pass through easily.

(ii) High coercive force (coercivity) H_c, generally above 10^4 A/m to resist demagnetization.

(iii) Appreciable remanent flux density to retain magnetization.

(iv) High Curie Temperature to minimize easy demagnetization.

48. (b)

Paramagnetic materials have atoms or ions with permanent magnetic moment that are randomly oriented due to thermal agitation. In the presence of an external magnetic field, these moments tend to align partially with the field producing weak magnetization and a small positive susceptibility.

49. (a)

At low frequencies (power frequencies), all polarization mechanisms in the material—electronic, ionic, orientational, and interfacial (space charge) contribute to the total polarization. This results in the maximum value for the dielectric constant. Whereas at extremely high frequencies, only the electronic polarization can keep up with the field reversals, resulting in the minimum value of the dielectric constant (often approaching unity).

50. (b)

Stored energy, $E_1 = \frac{1}{2}CV^2$ (without dielectric)

and $E_2 = \frac{1}{2}kCV^2$ (with dielectric)

as C increases 'k' times with introduction of dielectric, where k is dielectric constant

$\because$ $C = \frac{\epsilon_r \epsilon_0 A}{d} = \frac{k \epsilon_0 A}{d}$

It is given that $E_2 = 3E_1$, hence $k = 3$.

❍❍❍❍