Part A

PART – A '2' MARKS Q & A

1. Define phase.

Phase is defined as a physically and chemically homogeneous part of a system under study. It requires a unique structure, uniform composition and well defined boundaries or interfaces.

2. State phase rule.

The Phase rule states that a relation between number of phases, component and variables of a system. It is a simple mathematical expressions. It is used to calculate the degree of freedom of the system under given condition.

$F = C - P + n$

where F- Number of degree of freedom of the system

C- Number of components in the system

P- Number phases that exist in a system under certain condition

n- Number of variables. Example: Temperature, pressure and composition

3. Mention the advantages of Phase rule.

The advantages of the Phase rule are

i) The phase rule provides a convenient method for classification of equilibrium states of a system with the help of phases, components and degrees of freedom.
ii) The phase rule predicts the behaviour of system with changes in intensive variables such as temperature, pressure and composition.
iii) The phase rule indicates that different systems having the same number of degrees of freedom behave in the same manner.
iv) The phase rule is applicable to macroscopic system and therefore, information about the molecular structure is not necessary.

4. What are the limitation of phase rule?

The limitations of Phase Rule are

i) The phase rule is applicable only for the systems in equilibrium and it is no use for the systems which attain the state of equilibrium very slowly.
ii) The Phase rule is applicable to a single equilibrium state and does not indicate about the
iii) other possible equilibrium states in the system.
iv) The Phase rule considers only the intensive variables such as temperature, pressure and composition. It does not consider the influence of other factors like electric or magnetic field.

v) The Phase rule requires all the phases to be present under the same conditions of temperature and pressure.

5. What is a phase diagram?

Phase diagram is a graphical representation formed by plotting the values of independent intensive variables like pressure, temperature and composition for equilibrium condition between two phases.

6. Mention the uses of phase diagrams.

The uses of Phase diagrams are

i) To calculate the relative amount of phases present in a two phase alloy.
ii) To determine the number, type and composition of the phases present in any given alloy at a particular temperature.
iii) To predict the temperature at which freezing or melting will begin.
iv) The phase diagram is helpful in predicting phase transformations and resulting microstructure.

7. List the limitations of phase diagrams.

The limitations of Phase diagrams are

i) They do not tell as anything about the size of the micro-constituent present.
ii) Diagrams do not give any information about the physical and mechanical properties of the materials.

8. Write the types of phase diagram.

The phase diagrams are classified on the basis of the number of components in the system. They are

(i) Unary or single-component phase diagram
ii) Binary or two-component phase diagram
iii) Ternary or three-component phase diagram

9. What is single component system?

Single Component system is a simplest type of phase diagram to understand,there is only one component present. In single component system, phase diagram has two independent variables pressure (P) and temperature (T). There is no composition variable.

10. Give the example for single component system.

Examples for single component system

Water system , Carbon system and Iron.

11. What is binary phase diagram?

The binary phase diagram is obtained for the two components which completely dissolve in each other in all proportions in the liquid state but either partly or completely insoluble in the solid state.

For such a system, the two components must have the same crystal structure and should fulfil the Hume - Rothery's conditions.

12. Mention few important binary alloy system.

Some important binary alloy systems are

i) Completely soluble in the solid state – isomorphous system.
ii) Insoluble in the solid state – Eutectic system (I type).
iii) Partially soluble in the solid state – Eutectic system (II type).
iv) Peritectic system.

13. What is isomorphous system?

In isomorphous system, the two components are completely soluble in both liquid and solid states. In this system, only a single type of crystal structure exists for all the compositions of components. Therefore, it is called isomorphous system.

14. Give the examples for isomorphous system

Example for isomorphous system are

i) Aluminia - Chromia (Al_2O_3 - Cr_2O_3) system.
ii) Copper - Nickel (Cu - Ni) system.
iii) Antimony - Bismuth (Sb - Bi) system.
iv) Gold-Silver (Au - Ag) system.

15. What is the tie-line rule.

The tie-line is a horizontal line drawn on a two phase region of a binary phase diagram to determine the composition of two phases.

16. What is Lever rule?

The lever rule is used to calculate the relative proportions of solid and liquid material present in the mixture at any given temperature.

17. Mention some important reaction in phase diagram

Some important reactions in phase diagram are

- Eutectic reaction
- Peritectic reaction
- Eutectoid reaction
- Peritectoid reaction

18. Relate the eutectic reaction and phase diagram.

A reaction wherein upon cooling, a liquid phase transforms isothermally and reversibly into the phases is known as eutectic reaction.

When solid solubility is limited and the melting points of the components are not vastly different, an eutectic phase diagram usually is formed.

19. Give example for eutectic phase diagram

The example for eutectic phase diagram are

i) Copper - Silver (Cu - Ag) system
ii) Lead - Tin (Pb - Sn) system
iii) Aluminium - Copper (Al - Cu) system

20. Mention the uses of eutectic system.

The uses of eutectic system are

i) Eutectic mixtures are used in preparing "solders" used for joining two metal pieces together. Ex: Pb - Sn solders.

ii) They are used in "safety fuses" used in buildings to protect them against fire hazards. Ex: Woods metal, which is an alloy containing (50% Bi + 25% Pb + 12.5% Sn + 12.5% Cd).

21. What is the peritectic phase diagram.

When the melting point of the components are vastly different from each other, a peritectic phase diagram is formed.

22. Define invariant reaction.

The reaction which is having zero degree of freedom is called invariant reaction.

Example: eutectic reaction

23. What is nucleation?.

Nucleation is seen that the atoms are not chaotically arranged in a liquid metal as they are in the gaseous state; but at the same time they do not have the regular orderly characteristic of a solid (crystal) body.

At a temperature some what lower than T_s (melting temperature), micro volumes having atomic arrangement similar to that in the solid metal acquire higher stability and become centers of crystallization (nuclei or embryos). This is called as nucleation.

24. What is homogeneous nucleation?

In homogeneous nucleation the stability of a nucleus is controlled by two factors

i) the free energy change during the liquid – solid transition.
ii) the value of the surface energy of the nucleus thus formed.

As a result, the total free energy change associated with the embryo formation is given by

$$\Delta G = \frac{4}{3}\pi r^3 \Delta G_0 + 4\pi r^2 \gamma$$

where

ΔG_0 - free energy change between liquid and solid per unit volume.
γ - specific surface energy.
r - radius of an embryo considered to be spherical

25. What are the preparing methods of thin film.

Thin film preparing methods are broadly (mainly) classified into three categories, i.e.,

i) Physical vapour deposition (Thermal evaporation).

ii) Cathodic sputtering.

iii) Chemical vapour deposition (Chemical methods).

26. What are nanomaterials?

Nano materials are newly developed materials with grain size at the nanometer range (10^{-9} m) i.e., in the order of 1 – 100 nm. The particle size in nano material is in the order of nm.

27. What is solvothermal method?

Solvothermal synthesis is a method in which the precursor solution in an aqueous or organic phase is kept in an autoclave at high temperature and pressure to assist in the process of crystal growth.

28. What is the principle of sol - gel method?

Sol-gel method involves formation of '**sols**' in a liquid and then connecting the sol particles (or some sub-units capable of forming a porous network) to form a network.

By drying the liquid, it is possible to obtain powders, thin films or even monolithic solid.

29. Mention the methods for sol - gel formation.

In sol-gel formation, first sol can be obtained by the following methods.

a) Hydrolysis.

b) Condensation and polymerization of monomers to form particles.

c) Agglomeration of particles.

PART A QUESTIONS AND ANSWERS

1. List out the three main theories developed for metals.

The following are the main theories developed for metals :

(i) Classical free electron theory, which is a macroscopic theory obeying classical laws.

(ii) Quantum free electron theory, which is a microscopic theory obeying quantum laws.

(iii) Zone theory (or) band theory is also a microscope theory which is based on the energy bands of solids.

2. Give the postulates/assumptions of classical free electron theory.(A.U Chennai June 2009)

The postulates/assumptions of classical free electron theory are

(i) The free electrons in the metal move freely, similar to the gas molecules moving in a vessel and it obeys the classical kinetic theory of gases.

(ii) These free electrons move in a constant potential field due to ions fixed in the lattice.

(iii) When field is applied the free electron moves in the direction opposite to that of the field direction.

(iv) Due to field applied, they acquire a velocity called drift velocity and the electron velocities in the metal obey the Maxwell – Boltzmann statistics.

3. Define Drift velocity and give its formula.(A.U Chennai June 2010, A.U Chennai June 2009, A.U Chennai June 2014, A.U Chennai Dec 2016)

Drift velocity is defined as the average velocity acquired by the free electron in a particular direction, due to the application of an electric field and is denoted by the letter v_d.

Formula: $v_d = \lambda / \tau_c$ (m/s) Where λ = mean free path

τ_c = mean collision time

4. Define mean free path and mean collision time. (A.U Covai Dec 2010, A.U Covai June 2009)

The average distance travelled by the free electron between two successive collisions is called mean free path. It is denoted by 'λ' . The average time taken by the free electron between two successive collisions is called **mean collision time.** It is denoted by 'τ_c'

Mean free path $\lambda = v_d \tau_c$

where v_d = drift velocity and τ_c = Collision time

5. Define Mobility of Electrons. Write its unit. (A.U Covai Dec 2010, A.U Chennai April 2005, A.U Chennai June 2009, A.U Tirunelveli June 2010, A.U Chennai April 2015)

Mobility of an electron is defined as the velocity acquired by the electron per unit electric field.(E). (i..e) $\mu = v_d / E$ $m^2V^{-1}s^{-1}$

6.Define electrical conductivity. (**A.U Chennai June 2009, A.U Chennai April 2004**)

The electrical conductivity is defined as the quantity of electricity flowing (Q) per unit area (A) per unit time (t) maintained in unit electric field (E). Unit: $\Omega^{-1} M^{-1}$

$$\sigma = \frac{Q}{tAE}$$

7. Define Thermal conductivity. (A.U Chennai June 2009, A.U Chennai April 2004)

Thermal conductivity is defined as the quantity of heat conducted per unit area per unit time maintained at unit temperature gradient.

$$K = \frac{Q}{tA\frac{dT}{dx}}$$

8. State Wiedemann – Franz law. (A.U Covai Dec 2010, A.U Covai June 2010, A.U Chennai Dec 2009, A.U Tirunelveli May 2009, A.U Chennai June 2007, A.U Chennai Nov 2015 R2008, A.U Chennai Dec 2016)

Wiedemann – Franz law is stated as, "the ratio between the thermal conductivity (K) and the electrical conductivity (σ) of a metal is directly proportional to the absolute temperature (T) of the metal".

9. Distinguish between electrical conductivity and thermal conductivity. (A.U Chennai June 2007)

S.No	**Electrical conductivity**	**Thermal conductivity**
1.	Electrical conductivity is defined as the quantity of electricity flowing per unit area per unit potential gradient.	Thermal conductivity is defined as the quantity of heat conducted per unit area per unit time maintained at unit temperature gradient.
2.	Electrical conductivity is purely due to number of free electrons.	Thermal conductivity is due to both free electrons and phonons.
3.	Conduction of electricity takes place from higher potential end to the lower end.	Conduction of heat takes place from hot end to cold end.

10. Get the microscopic form of Ohm's law and state whether it is true for all temperatures. (A.U Covai June 2009)

According to classical free electron theory current density

$$\mathbf{J = \sigma E}$$

Where $\boldsymbol{\sigma}$ = electrical conductivity

Since conductivity ($\boldsymbol{\sigma}$) = 1/Resistivity (ρ)

We can write $\mathbf{E = J \rho}$

For a conductor of length 'l' and area of cross section 'A'

Resistance = $\boldsymbol{\rho l / A}$

Therefore Voltage $\mathbf{V} = \mathrm{I}\, \boldsymbol{\rho l / A}$

(or) V = IR

Therefore microscopically we can write V = IR as E = Jρ

Since the resistivity varies with respect to the temperature, the microscopic form of Ohm's law is not true for all the temperatures.

11. What are the successes or merits of classical free electron theory?(A.U Chennai Nov 2014, A.U Chennai April 2015)

The followings are the success of classical free electron theory :

(i) It verifies Ohms law.

(ii) It explains the electrical and thermal conductivity of metals.

(iii) It is used to derive Wiedemann – Franz law.

(iv) The optical properties of metals can be explained using this theory.

12. What are the drawbacks (or) demerits of classical free electron theory? (A.U Covai Dec 2010, A.U Trichy Dec 2009, A.U Chennai June 2010, A.U Chennai June 2009, A.U Chennai June 2005, A.U Chennai June 2007, A.U Chennai Nov 2014, A.U Chennai April 2015, A.U Chennai Nov 2015 R2008)

The drawbacks of classical free electron theory are

a) It is a macroscopic theory. Classical theory states that all free electrons will absorb energy, but quantum theory states that only few electrons will absorb energy.
b) This theory cannot explains the Compton effect, photo – electric effect, para and ferromagnetism, etc.
c) The theoretical and experimental values of specific heat capacity is incorrect.

d) From classical theory $\frac{K}{T\sigma} = Constant$ for all temperatures. But according to Quantum theory $\frac{K}{T\sigma} \neq Constant$ for all temperatures.

e) The Lorentz number by classical theory does not have good agreement with the experimental value and is rectified by quantum theory.

13.Define Fermi energy level and Fermi energy with its importance. (A.U Trichy June 2010, A.U Chennai June 2010, A.U Chennai June 2009, A.U Chennai Nov 2005, A.U Chennai June 2007)

Fermi energy level is the highest reference energy level of a particle at absolute zero. **Importance:** It is the reference energy level which separates the filled energy levels and vacant energy levels.

Fermi energy (E_F) is the maximum energy of the quantum state corresponding to Fermi energy level at absolute zero temperature.

Importance: Fermi energy determines the energy of the particle at any temperature.

14.Write the Fermi - Dirac distribution function and give its importance. (A.U Covai June 2010, A.U Chennai April 2004)

Fermi function F (E): Fermi – Dirac distribution function represents the probability of occupying a given energy level. It is given by

$$[F(E)] = \frac{1}{1 + exp[(E - E_f)/kT]}$$

where k = Boltzmann constant & T = Absolute Temperature

Importance: It gives the probability of filling the electron within the Fermi energy level.

For example of F (E) = 0.7 means, there is 70% chance for filling an electron within the Fermi energy level.

15. How does the Fermi function varies with temperature?(A.U Chennai Nov 2007, A.U Trichy June 2009)

The Fermi function at 0 K for all the energy states below E_{Fo} are filled and all those above it are empty. When the temperature is increased, the electron takes an energy k_BT and hence the Fermi function falls to zero.

16. Evaluate the value of Fermi Distribution function for an energy kT above the Fermi energy. (A.U Chennai May 2004, A.U Covai June 2009)

Given: $E - E_f = KT$

Solution: Fermi distribution function

$$[F(E)] = \frac{1}{1 + exp\left[\left(E - E_f\right)/kT\right]}$$

$$[F(E)] = \frac{1}{1 + exp[1]} = \frac{1}{1 + 2.718} = 0.269$$

Fermi distribution function [F (E)] = 0.269

17. Define density of states and given an example and state its importance. (A.U Trichy June 2010, A.U Chennai June 2010, A.U Chennai June 2009, A.U Chennai Dec 2003) or Define density of states and sketch the same for a metal. (A.U Chennai May 2008)

Definition: Density of states Z (E) dE is defined as the number of available energy states per unit volume in an energy interval dE.

Example: We can say the density of states of a cubical metal piece as

$$Z(E)dE = \frac{\text{Number of available energy states between } E \text{ and } E + dE \text{ in a cubical metal piece}}{\text{Volume of that cubical metal piece}}$$

Importance : It is used to calculate the number of charge carriers per unit volume of any solid.

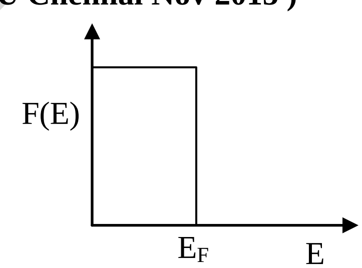
18. What do you mean by carrier concentration in metal? (A.U Covai June 2009)

In metal the **carrier concentration** is the number of free electrons per unit volume in between the energy interval 0 to E_f. It is given by

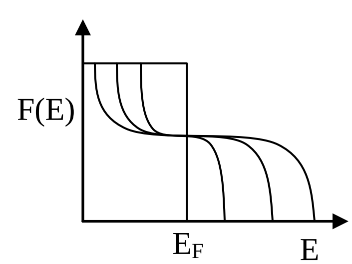
Carrier concentration (N) = $\int_0^{E_f} \text{Density of states} \times \text{Fermi distribution function}$

$$N = \int_0^{E_f} N(E).F(E)dE$$

19. Draw qualitatively Fermi-Dirac distribution function at T = 0K and at a temperature T > 0K. (A.U Chennai Nov 2015)



T = 0 K



T > 0 K

20. Define scattering power of the potential barrier.

Scattering power of potential barrier is defined as the strength with which the electrons are attracted by the positive ion.

21. Will the effective mass of the electron be negative? Justify your answer.

Yes, the effective mass of the electron can also have a negative value.

Justification: The effective mass of the electron is the mass of the electron when it is accelerated in a periodic potential and is given by

$$m* = \frac{h^2}{d^2E/dk^2}$$

Here, d^2E/dk^2 can vary from positive to negative value, therefore if d^2E/dk^2 is negative, then $m*$ will also have negative valu. Also, this negative effective mass of an electron leads to the concept of hole.

22. What are the phenomenon that explains the concept of hole?

There are two phenomenon which explains the concept of hole viz

(i) Hall effect

(ii) Thomson effect

23. What is meant by effective mass approximation?

For an electron moving in a constant potential field m*=m. But for an electron moving in a periodic potential m*≠ m. Thus, when electron moves in a periodic potential the free electron mass 'm' should be replaced by the effective mass m* and this process is called as **effective mass approximation**.

24. Compare free electron approximation and tight binding approximation.

S.no.	Free electron approximation	Tight binding approximation
1.	The potential energy of the electron is assumed to be lesser than its total energy	The potential energy of the electron is nearly equal to the total energy
2.	The width of the forbidden bands are smaller than allowed bands	The width of the forbidden bands is larger than the allowed bands.
3.	The interaction between the neighbouring atoms will be very strong	The interaction between the neighbouring atoms will be weak.

25. What is meant by degenerate and non-degenerate state.

Degeneracy: For several combination of quantum number have same energy eigen value but different eigen functions. Such states and energy levels are called Degenerate state.

Non-Degeneracy : For various combinations of quantum numbers if we have same energy eigen value and same eigen function then such states and energy levels are called non-degenerate state.

PART A QUESTIONS AND ANSWERS

SUPERCONDUCTING MATERIALS

1. What is called super conductivity? (A.U Trichy June 2010)

The phenomenon of losing the resistivity absolutely to zero, when cooled to sufficiently low temperature (i.e.,) below critical temperature (T_c) is called superconductivity.

2. What do you understand by the terms "critical temperature" and "critical field" of a superconductor?

(i) Critical Temperature: The temperature at which the normal conductor loses its resistivity and becomes a superconductor is known as transition temperature or critical temperature (T_c)

(ii) Critical field: The magnetic field required to destroy the superconducting property is called critical magnetic field (H_c). It is given as

$$H_c = H_0 \left[1 - \frac{T^2}{T_C^2}\right]$$

where, H_0 is critical field required to destroy the superconducting property at 0 K

H_c is the minimum field required to destroy the superconducting property at T K.

3. Mention the condition for a superconducting material to behave as superconductors. (A.U. Covai June 2009)

The following are the conditions for a material to behave as a superconductor.

(i) It should be cooled below transition temperature (i.e.,) the ideal resistivity due to scattering by phonons (ρ_T) should be zero.

(ii) It should be pure (i.e.,) the residual resistivity due to scattering by impurities (ρ_o) should be zero.

(iii) The magnetic induction in the material should be zero, when it is placed in external magnetic field.

4. Explain Meissner Effect. (A.U. Covai Dec 2010, A.U. Covai June 2010)

When the superconducting material is subjected to a uniform magnetic field, $H \leq H_c$ and below the critical temperature (T_c), the magnetic flux lines pushed out from the material. Thus, the magnetic induction (B) inside the material is zero and this property is called diamagnetism. This phenomenon is known as Meissner effect.

5. Mention any four property changes that occur in super conductor. (or) What are the properties of a superconductor?

The properties of a superconductor are

(i) They have zero resistivity.

(ii) They exhibit perfect diamagnetism.

(iii) The super conducting property can be destroyed due to the application of magnetic and electric fields.

(iv) The transition temperature varies due to the presence of isotopes.

(v) The entropy and specific heat decreases at transition temperature.

(vi) The elastic properties, crystal structure and thermal expansion remain constant.

6. Will the super conductor exhibits the property of diamagnetism? Explain.

Yes, the super conductor exhibits the property of diamagnetism.

Explanation: When a super conductor is kept in an external magnetic field the magnetic lines of forces are expelled by the superconductor. Similar to a diamagnetic material and hence we can say that the super conductor behaves as a perfect diamagnet.

7. What is meant by persistent current?

When d.c. current of large magnitude is once induced in a super conducting ring, then due to the diamagnetic property of the super conductor, the magnetic flux is trapped inside the ring and hence the current persists in the ring for a longer time. This current is called as persistent current.

8. Distinguish between D.C and A.C Josephson Effect.

S.No.	D.C Josephson effect	A.C. Josephson effect
1	When two super conducting materials are separated by an insulator of very few thickness and are connected by a wire, a d.c. Current flows in the external circuit and is called d.c. Josephson effect.	When two super conducting materials are separated by an insulator of very few thickness and are connected to a d.c. power, then a.c. microwaves are produced at the junction and this effect is called a.c. Josephson effect.
2	The current persists for a longer time.	The current persists only for a short time.

9. Differentiate between type I and Type II superconductors. (A.U Chennai June 2009, A.U Trichy June 2009, A.U Tirunelveli May 2009).

S.No.	Type I (Soft) Superconductor	Type II (Hard) Superconductor
1	The Type I super conductor becomes a normal conductor abruptly at critical magnetic field.	Type II super conductor loses its super conducting property gradually, due to increase in magnetic field.
2	Here we have only one critical field (H_c).	Here we have two critical field (i.e.,) Lower critical fields (H_{c1}) and Upper critical field (H_{c2})
3	No mixed state exists.	Mixed (or) vortex state is present.
4	Highest known critical field is 0.1 Tesla	The critical field is greater than Type I (i.e.,) upto 30 Teslas.

10. What is meant by high temperature and low temperature super conductors? On what basis they are classified.

On the basis of critical temperature superconductors are classified as low temperature and high temperature super conductors. If the transition temperature is low (i.e.,) say below 77 k, then it is termed as low temperature super conductors. If the transition temperature is high (i.e.,) above 77 k, then it is called high temperature super conductors.

11. Define Cooper pairs. (A.U Chennai June 2009, A.U Trichy June 2009, A.U Trichy Dec 2009, A.U Chennai Nov 2015)

The pair of electrons formed due to the electron – lattice – electron interaction, with equal and opposite momentum and spins having the wave vectors k – q and k + q are called Cooper pairs.

12. Write a short note on SQUIDS. (A.U Chennai June 2009, A.U Trichy June 2010, A.U Chennai May 2015, A.U Chennai Dec 2016)

SQUID is an abbreviation of Super conducting Quantum Interference Devices. It is an improved model of Josephson device and it works under the principle that, "A small change in magnetic field produces large variation in the quantum flux"

Applications:

(i) It is used to detect the earth quakes

(ii) It is used to measure the poison levels of iron in lever.

(iii)It is used to detect the magnetic signals from brain, heart etc.

(iv)It is also used in storage devices.

13. What is a cryotron?

Cryotron is a type of switching element made by two different super conductors A and B, with critical fields $H_{CB} > H_{CA}$. Here the super conducting property vanishes for the material 'A' due to the magnetic field produced by material B and hence it can be used as relay (or) switching elements.

14. What is the principle of magnetic levitation?(A.U Chennai Nov 2015 R2008)

Principle: Electromagnetic induction is used as the principle (i.e.,) when there is a relative motion of a conductor across the magnetic field, current is induced in the conductor and vice versa.

Here the train is initially made to slide over the rails and then levitated by inducing current in the "8" shaped coils. Now by alternatively changing the poles of the super conducting magnet fixed in the train, the train can be moved faster.

PART A QUESTIONS AND ANSWERS

1. State the properties of a semiconductor. (A.U. Covai June 2009, A.U. Chennai May 2003, A.U Chennai June 2014)

The properties of a semiconductor are

(i) The resistivity lies between 10^{-4} to 0.5 ohm-meter.

(ii) At 0K, they behave as insulators.

(iii) The conductivity of a semiconductor increases due to temperature and impurities.

(iv) They have negative temperature coefficient of resistance.

(v) In semiconductors both the electron and holes are charge carriers and will take part in conduction.

2. What happens when the temperature increases in the case of semiconductor and conductor? (A.U. Tirunelveli June 2010, A.U Chennai April 2015)

The reason behind the increase in temperature as follows:

(i) With increase of temperature, the conductivity of semiconductors increases and hence resistivity decreases because more and more charge carriers are created by the temperature.

(ii) In case of metals, there is no change in the concentration of the charge carriers by the increase in temperature. The additional thermal energy induces the collisions of electrons with the lattice ions and hence the resistivity increases and conductivity decreases.

3. What is meant by intrinsic semiconductor and extrinsic semiconductor? What are the differences between intrinsic and extrinsic semiconductor? (A.U. Covai June 2009, A.U. Chennai June 2009, A.U. Chennai Nov 2003, A.U. Chennai Dec 2003, A.U Chennai Nov 2015 R2008)

S.No.	Intrinsic semiconductor	Extrinsic semiconductor
1	Semiconductor in a pure form is called intrinsic semi conductor.	Semiconductors which are doped with impurity is called extrinsic semiconductor.
2	Charge carriers are produced only due to thermal agitation.	Charge carriers are produced due to impurities and due to thermal agitation.

3	They have low electrical conductivity.	They have high electrical conductivity.
4	They have low operating temperature.	They have high operating temperature.
5	At 0K, the Fermi level exactly lies between conduction band and valence band. **Examples**: Si, Ge, etc.	At 0K, Fermi level lies closer to conduction band in "n" type and lies near valence band in "p" type. **Examples:** Si, doped with Al, P

4. What is meant by energy band gap?

Energy band gap (E_g) is defined as the energy difference between the minimum energy of conduction band (E_c) and the maximum energy of the valence band (E_v).

5. Compare elemental and compound semiconductor. (or) What are the differences between indirect band gap semiconductor and direct band gap semiconductor? (A.U. Trichy June 2009, A.U. Chennai April 2002, A.U Chennai Nov 2014, A.U Chennai April 2015)

S.No.	Elemental Semiconductor	Compound Semiconductor
1	They are made of single element E.g: Ge, Si, etc	They are made of compounds. Eg: GaAs, GaP, Cds, MgO etc.
2	They are called as indirect band gap semiconductors. i.e. electron – hole recombination takes place through traps, present in the band gap.	They are called as direct band gap semiconductors. i.e., electron – hole recombination takes place directly with each other.
3.	Here heat is produced due to recombination.	Here photons are emitted during recombination (this effect is in LED).
4	Life time of charge carriers is more due to indirect recombination.	Life time of charge carrier is less due to direct recombination.
5	Current amplification is more.	Current amplification is less.
6	They are used for the manufacture of diodes and transistors.	They are used for making LED's laser diodes, IC's.

6. Why do we prefer silicon for transistors and GaAs or Germanium for laser diodes? (A.U. Covai June 2009, A.U Chennai Dec 2016))

Silicon is an indirect band gap semiconductor for which the life time of the charge carriers is more and the current amplification is also very high, hence it is preferable for using it in transistors. GaAs or Ge is a direct band gap semiconductor, in which electrons and holes recombine directly to produce photons and hence used in laser diodes.

7. Give the expression for carrier concentration of an intrinsic semiconductor. (A.U. Covai June 2010)

Intrinsic Carrier concentration of an intrinsic semiconductor is given by

$$n_i = 2\left[\frac{2\pi kT}{h^2}\right]^{3/2} (m_e^* m_h^*)^{3/4}\, exp\left[\frac{-E_g}{2kT}\right]$$

where m_e^* , m_h^*= effective mass of electron and hole respectively.

8. Compare n-type and p-type semiconductors.(A.U. Covai Dec 2010, A.U. Chennai Nov 2009, A.U. Chennai June 2010)

S.No.	**n-type semiconductor**	**p-type semiconductor**
1	n-type semiconductor is obtained by doping an intrinsic semiconductor with pentavalent impurity.	p-type semiconductor is obtained by doping an intrinsic semiconductor with a trivalent impurity.
2	Here electrons are majority carriers and holes are minority carriers.	Here holes are majority carriers and electrons are minority carriers.
3	It has donor energy levels very close to conduction band.	It has acceptor energy levels very close to valence band.
4	When temperature is increased, these semiconductors can easily donate an electron from donor energy level to the conduction band.	When temperature is increased, these semiconductors can easily accept an electron from valence band to acceptor energy level.

9. Define donors and acceptors.

Donors: Donors are the pentavalent impurity atoms like P, As,etc., which donates an electron to the pure semiconductors like Ge (or) Si. These energy levels are called donor energy level.

Acceptors: Acceptors are the trivalent impurity atoms like Ga, In, etc which can easily accept an electron from the pure semiconductors like Ge (or) Si. These energy levels are called acceptor energy level.

10. Discuss the variation of Fermi level with temperature for p and n type semiconductors.

P-type: When the temperature is increased for a p-type semiconductor, some of the electrons in the valence band goes to acceptor energy levels and hence the Fermi level is shifted towards upward direction.

n-type: When the temperature is increased for an n-type semiconductor, some electrons are shifted from donor energy level to the conduction band and hence the Fermi energy level is shifted down.

11.What is meant by the terms Hall effect, Hall voltage and Hall coefficient? (A.U. Chennai Nov 2009, A.U. Chennai June 2010, A.U. Trichy June 2010, A.U. Tirunelveli May 2009)

Hall Effect: When a current carrying conductor is placed in a transverse magnetic field, an electric field is produced inside the conductor in a direction normal to both current and the magnetic field. This effect is known as Hall Effect.

$$R_H = \frac{V_H t}{IB}\, m^3 \text{ per Coulomb}$$

where V_H = Hall Voltage, t = Thickness,

I = Current and B = Magnetic flux density.

Hall voltage: The generated voltage is called Hall voltage.

Hall coefficient: Hall field per unit current density per unit magnetic induction is called Hall coefficient.

12. How can you distinguish p- type and n-type semiconductors using Hall Effect? (A.U. Tirunelveli June 2010)

The n-type and p-type semiconductors can be distinguished by determining the Hall coefficient using Hall Effect. (i.,e) If the R_H is negative then we can ensure that the material is an n-type semiconductor rather if the R_H is positive, then we can say that the material is a p-type semiconductor.

13. What are the applications of Hall Effect? (A.U. Covai Dec 2010, A.U. Chennai June 2010, A.U. Chennai Nov 2003, A.U. Chennai May 2005)

The following are the Hall Effect of applications :

(i) It is used to determine whether the material is p – type or n – type semiconductor. R_H is negative for n – type and R_H is positive for p – type semiconductor.

(ii) It is used to find the carrier concentration. n_e and n_h

(iii) It is used to find mobility of charge carriers μ_e and μ_h.

(v) It is used to design magnetic flux meters and multipliers on the basis of Hall voltage.

(vi) It is used to find the power flow in an electromagnetic wave.

14. What is meant by the law of mass action in semiconductor? (A.U Chennai June 2014)

The law of mass action states that in the case of any semiconductors in thermal equilibrium, the product of number of holes and number of electrons is a constant. In intrinsic semiconductor, the number of free electrons is equal to number of vacancy or holes.

i.e n=p and np = constant

15. Write the working principle of LED .

The working principle of LED is the injection of electrons into the p - region from n-region makes a direct transition from the conduction band to valence band. Then, the electrons recombine with holes and emits photons of energy E_g.

The forbidden gap energy is given by $E_g = h\nu$.

16. What are the advantages and Disadvantages of LED?

Advantages of LED's are

(i) LEDs are smaller in size. A number of LEDs can be stacked together in a small space to form numerical display.

(ii) LED's can be turned ON and OFF in less than 1 nano second (10^{-9} second). So, they are known as fast devices.

(iii) Variety of LEDs are available which emit light in different colours like red, green, yellow etc.

(iv) Light modulation can be achieved with pulse supply.

(v) LED has long life time.

(vi) LED has low drive voltage and low noise.

(vii) LED is easily interfaced to digital logic circuits.

(viii) LED can be operated over a wide range of temperatures.

Disadvantages of LED's are

(i) They require high power.

(ii) Their preparation cost is high when compared to LCD.

17. Define Solar Cell .

Solar Cell is a p – n junction diode which converts solar energy (light energy) into electrical energy.

18. What are the applications of Solar cell ?

The applications of Solar cell are

(i) Solar cells are used in satellites and space vehicles to supply power to electronic and other equipments and to charge storage batteries.

(ii) They are used to give power to the calculators and watches.

(iii) They are used to provide commercial electricity.

PART A QUESTIONS AND ANSWERS

MAGNETIC MATERIALS

1. What is Bohr Magneton? (A.U. Covai Dec 2010, A.U. Covai June 2010, A.U. Trichy Nov 2009, A.U Chennai Nov 2014, A.U Chennai Dec2016)

When the atom is placed in a magnetic field, the orbital magnetic moment of the electrons is quantized. A quantum of magnetic moment of an atomic system is known as Bohr Magneton.

$$\mu_B = \frac{eh}{4\pi m} = 9.27 \text{ x } 10^{-24} \text{ Am}^2$$

2. On the basis of spin how the materials are classified. (A.U. Covai June 2009)

Based of spin of electron the materials are classified as follows

(i) Diamagnetic materials do not have any unpaired electron.

(ii) Paramagnetic materials have few unpaired electron spins of equal magnitudes

(iii) Ferro magnetic materials have many unpaired electron spins with equal magnitudes.

(iv) Anti Ferro magnetic materials have equal magnitude of spins but in anti parallel manner.

(v) Ferrimagnetic materials have spins in anti parallel manner but with unequal magnitudes.

3. What are the properties of diamagnetic materials?

The properties of diamagnetic materials are

(i) Diamagnetic materials repel magnetic lines of forces.

(ii) There is no permanent dipole moment. Therefore the magnetic effects are very small.

(iii)The magnetic susceptibility is negative and independent of temperature.

4. What are the properties of paramagnetic materials?

The properties of paramagnetic materials are

(i) Paramagnetic materials possess permanent magnetic dipoles.

(ii) When placed inside a magnetic field, it attracts the magnetic lines of forces.

(iii)There is a small amount of resultant magnetic moment in each atom, even in the absence of the magnetic field,

(iv)Susceptibility is positive and dependent on temperature.

5. What do you understand by the term "magnetic domains" and "domain walls"?

Magnetic domains are the small regions in a ferromagnetic material which has a group of atoms. These atoms can be completely magnetized by favorable exchange spin-spin interaction. The walls of these small regions (or) domains are called domain walls.

6. What is domain theory of Ferro magnetism? (A.U. Chennai Nov 2009, A.U Chennai Nov 2015)

The domain theory of ferromagnetism is the explanation of the structure and hysteresis property of ferromagnetic materials based on the concept of domains proposed by Weiss. Domain is the small region completely magnetized in one direction.

Importance: It gives the maximum energy stored in the magnets which helps in distinguishing a weak and strong magnet. Therefore for permanent magnets the value of energy product should be very high.

7. What are the four types of energies involves in the growth of magnetic domains? (A.U. Trichy June 2009)

The four types of energies involved in the growth of magnetic domains are

(i) Exchange energy (or) magneto static energy.

(ii) Anisotropy energy.

(iii) Domain wall energy.

(iv) Magneto stricture energy.

8. What is Hysteresis?

The lagging of magnetic induction (B) behind the applied field strength is called hysteresis.

9. Distinguish between soft and hard magnets. (A.U. Chennai June 2009 A.U. Trichy June 2010)

S.No.	Soft Magnets	Hard Magnets
1	They can be easily magnetized and demagnetized.	They cannot be easily magnetized (or) demagnetized.
2	Loop area is less and hence the hysteresis loss is minimum.	The loop area is large and hence the hysteresis loss is maximum.
3	Susceptibility and permeability is high.	Susceptibility and permeability is low.

4	Receptivity and coercivity are small.	Receptivity and coercivity are large.
5	These materials are free from irregularities like strain or impurities.	These materials have large amount of impurities and lattice defects.

10. Explain the term retentivity and coercivity and its units.

Retentivity is the residual intensity of magnetization retained by the specimen even when the external magnetic field is cutoff. **Unit :** Wbm^{-2}

Coercity is the strength of reverse magnetic field required to completely remove the residual magnetization (or) demagnetize the material. **Unit:** Ampere turn / meter.

11. What do you mean by energy product? (A.U. Chennai Nov 2009, A.U. Covai June 2009)

The product of retentivity (B_r) and the coercivity (H_c) is known as energy product. It represents the maximum amount energy stored in the specimen.

12. Classify Ferromagnetic materials based on their spin type. (A.U. Covai June 2010)

Ferro magnetic materials have many unpaired electron spins with equal magnitudes.

(i) Anti Ferro magnetic materials have equal spin magnitude but in anti parallel manner.

(ii) Ferromagnetic materials have anti parallel spins with unequal magnitudes.

13. Define anti-ferromagnetism. Mention two materials that exhibit anti-ferromagnetism. (A.U. Chennai June 2010, A.U Chennai Nov 2015 R2008)

In anti-ferromagnetism, electron spin of neighbouring atoms are align antiparallel. Antiferromagnetic susceptibility is small and positive and it depends greatly on temperature. Example: Manganese Oxide and Chromium Oxide.

14. What are Ferrites? (A.U. Tirunelveli June 2010)

Ferrites are the modified structure of iron with no carbon in which the magnetic moments are of unequal magnitudes. They are made by two(or) more different kinds of atoms. Its general formula is given by $X^{2+}F_e{}^{3}{}_{2}{}^{+}O_4$

Where X^{2+} is a divalent metal ion such as Mg^{2+}, Zn^{2+}, Fe^{2+}, etc.

15. What are the applications of ferrites? (A.U. Covai Dec 2010, A.U Chennai May 2015)

The applications of ferrites are

(i) They are used in digital computers and data processing circuits as magnetic storage elements.

(ii) They are used in transformer cores for high frequencies upto microwaves.

(iii)They are used in switching circuits and parametric amplifiers.

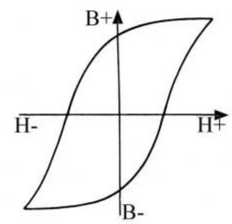
(iv)They are used in two port devices such as gyrator, circulator and isolator.

16. Give Curie-Weiss law and its importanc.(A.U Chennai June 2014)

Curie-Weiss law is derived by introducing the concept of internal molecular field. According to this law,

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

where, C is Curie constant and θ is the paramagnetic Curie temperature. This law explains the relationship between para and ferromagnetism.



17. **What is meant by hysteresis loop and what do you infer from it? (A.U Chennai May 2003, A.U Chennai June 2014)**

The hysteresis loop of ferromagnetic materials refers to the lag of magnetization behind the magnetizing field. It is an irreversible B-H characteristic curve of ferromagnetic or ferromagnetic materials.

- It is hysteresis curve is broad and has a large area, it is known as hard magnetic material.
- If hysteresis curve is sharp and has a small area, the hysteresis loss is small and is known as soft magnetic material.

PART A QUESTIONS AND ANSWERS

DIELECTRIC MATERIALS

1. List the characteristics of a good dielectric material. (A.U. Covai June 2009, A.U. Tirunelveli June 2010, A.U Chennai June 2014)

The characteristics of a good dielectric material are

a) They are non-metallic.
b) They have high specific resistance.
c) They have negative temperature coefficient.
d) The energy gap should be more 3eV.
e) They have high dielectric constant.

2. Compare active and passive dielectrics. (or) Mention any two active and passive dielectrics with their applications. (A.U. Chennai May 2007, A.U. Covai June 2009, A.U. Trichy Nov 2009)

S.No.	Active dielectrics	Passive dielectrics
1	Dielectrics which can easily adapt itself to store the electrical energy in it is called active dielectrics.	Dielectrics which restrict the flow of electrical energy in it are called passive dielectrics.
2	They exhibit gain and directional properties.	They exhibit no gain and no directional properties.
3	Example: Piezo electrics Ferro electrics, Pyro electrics.	Example: Ceramics, Glass, mica, plastic.
4	It is used in the application of ultrasonic.	It is used in production of sheets pipes etc.,

3. Define Dielectric Constant. (A.U. Covai June 2010, A.U. Trichy June 2010, A.U. Covai Dec 2010)

Dielectric constant is the measure of the polarization produced in the material. It is the ratio between the absolute permittivity and the permittivity of the free space.

(ie) $\epsilon_r = \epsilon / \epsilon_0$

4. Define electronic polarization.(A.U. Tirunelveli June 2010)

When a dielectric material is kept in external field (E), the positive and negative charges in the dielectrics moves in opposite direction, thereby creating a dipole moment. This process in known as electronic polarization.

The induced dipole moment $\mu = \alpha_e E$ [α_e = electronic polarizability.]

5. What is Ionic polarization? (A.U. Chennai June 2006, A.U. Chennai Nov 2009, A.U. Chennai June 2010, A.U. Covai Dec 2010)

The process of displacement of cations and anions in the opposite direction, of a dielectric material kept in external electric field (E) is called ionic polarization.

Ionic Polarizability is given by

$$\alpha_i = \frac{e^2}{\omega_0^2}\left(\frac{1}{M} + \frac{1}{m}\right)$$

6. What is Orientation Polarization? (A.U. Chennai June 2006, A.U. Chennai Nov 2009)

When the field is applied, positive portion align along the direction of field and negative portion align in the opposite direction of the field. This is called Orientation Polarization.

7. What are the differences between polar and non polar molecules?

S.No.	Polar molecule	Non – polar molecules
1	These molecules have permanent dipole moments even in the absence of an applied field.	These molecules do not have permanent dipole moments.
2	The polarization of polar molecules is highly temperature dependent	The polarization of molecules is independent of temperature.
3	These molecules do not have symmetrical structure and they do not have centre of symmetry.	These molecules have symmetrical structure and they have centre of symmetry
4	For this kind of molecules, there is absorption or emission, in the infrared range. Examples:$CHCl_3$, H_2O, HCL.	For these molecules, there is no absorption or emission in the range of infrared Example: CCl_4, CO_2, H_2.

8. How polarization varies with temperature? (A.U. Covai June 2009, A.U. Tirunelveli June 2009, A.U Chennai Nov 2015 R2008)

(i) The electronic and ionic polarizations are practically independent on temperature.

(ii) Orientation polarization decreases with increase in temperature.

(iii) Space Charge polarization increases with decreases in temperature.

9. Define local field in a dielectric material. (A.U. Chennai June 2010)

The force experienced by a dipole inside a dielectric is known as internal field or Lorentz local field. This field is due to the external field as well as other dipoles surrounding the central dipole in the dielectric medium.

10. What is Dielectric Loss and Loss Tangent? (A.U. Trichy June 2009, A.U. Tirunelveli June 2010, A.U Chennai April 2015)

When a dielectric is kept in an external electric field (E), the electrical energy is absorbed by the dielectric and certain amount of electrical energy is dissipated in the form of heat energy. This loss in energy in the form of heat is called dielectric loss.

The power loss $P_L \alpha \tan \delta$ where $\tan \delta$ is called loss tangent and is called loss angle. This dielectric loss mainly occurs due to the imaginary part of complex dielectric constant.

11. What is meant by dielectric breakdown and dielectric strength? (A.U. Trichy June 2010, A.U Chennai Nov 2014, A.U Chennai Dec 2016)

When external field applied to a dielectric material is greater than the critical field, the dielectric losses its insulating property and becomes conducting. Therefore a large current flows through the material. This phenomenon is called **dielectric breakdown.**

Dielectric strength is the minimum strength required per unit thickness of the dielectric material to produce dielectric breakdown.

12. Mention the various dielectric breakdown mechanisms. (A.U. Chennai June 2009)

(i) Intrinsic breakdown.

(ii) Thermal breakdown.

(iii) Discharge breakdown.

(iv) Electro chemical breakdown.

(v) Defect breakdown.

13. What is discharge breakdown and defect breakdown? (A.U. Chennai Nov 2009)

Discharge Breakdown: When dielectric is placed in an external electric field the occluded gas bubbles present in the material will easily ionize and produces large ionization current. This phenomenon is known as discharge breakdown.

Defect Breakdown: This breakdown occurs due to the defect such as pores, cracks etc, in the dielectric.

14. What are the various sources by which the power loss occurs in a dielectric? (A.U. Tirunelveli June 2010)

The factors affecting power loss are

Temperature, Applied voltage, Frequency and Humidity.

15. What is Ferro-electricity? (A.U. Chennai June 2009, A.U. Trichy June 2010, A.U. Trichy June 2009, A.U. Trichy Nov 2009)

When a dielectric material exhibits electric polarization even in the absence of external field is called Ferro-electricity. Such materials are called ferroelectric material. Eg: Rochelle salt.

16. State the properties of Ferroelectric Material. (A.U. Chennai June 2010)

The properties of Ferroelectric materials are

a) They are polarized even in the absence of electric field.
b) They have hysteresis effect.
c) They have very high dielectric constant.
d) They have domain structure. The domain wall is of the order of few lattice constants.

17. Write the applications of ferroelectric material. (A.U. Tirunelveli May 2009)

The applications of ferroelectric materials are

a) They are used as memory cores in computers.
b) Ferroelectric ceramics are used as capacitors to store electrical energy.
c) They are very good infra-red detectors.
d) Electrets are also useful for bonding fractured bones in our body.

18. Explain Lorentz force and Coulomb force in dielectrics (A.U. Chennai June 2010)

(i) Lorentz and Coulomb forces are opposite in nature in dielectric materials.

(ii) Lorentz force is the repulsive force between the nucleus and the electrons in a dielectric material when kept in external electric field.

(iii) Coulomb force is the attractive force between electrons and nucleus in the dielectric material.

19. What are the uses of dielectric materials? (A.U Chennai April 2015, A.U Chennai Nov 2015)

The uses of dielectric materials are

a) It is used as a dielectric medium in capacitors.
b) It is used as insulating materials in transformers.
c) It is used in industries as gas lighters, microphones and phonographs
d) It is used as dielectric heating.

20. What is thermal breakdown in dielectrics? (A.U Chennai Nov 2015 R2008)

When an electric field is applied to a dielectric material, some amount of heat is produced. This heat must be dissipated from the material.

Due to the excess of heat, the temperature inside the dielectric increases and may produce local melting in the dielectric material.

This type of breakdown is known as thermal breakdown.

21. Disdinguish between Paraelectric and ferroelectric materials.

S.No.	Paraelectric materials	Ferroelectric materials
1	Paraelectricity is the ability of many materials (specifically ceramic crystals) to become polarized under an applied electric field.	Some materials which exhibit electronic polarisation even in the absence of the applied electrical field and thus produce electricity.
2	No permanent electric dipole that exists in the material	They possess permanent electric dipoles.
3	The domains are unordered and the internal field is weak.	Internal electric field develops spontaneous polarization so the domains are aligned.

PART A QUESTIONS AND ANSWERS

1. What are metallic glasses? (A.U. Chennai Nov 2009, A.U Chennai Nov 2014, A.U Chennai June 2016)

Metallic glasses are amorphous metallic solids which have high strength, magnetic properties better corrosion resistance and will possess both the properties of metals and glasses.

2. Name the type of metallic glasses and mention few glasses. (A.U. Chennai June 2010, A.U. Tirunelveli June 2009)

Metallic glasses are of two types

(i) Metal – Metalloid glasses Eg: Metals: Metalloids

Fe, Co, Ni : Ge, Si, B, C

(ii) Metal – Metal glasses Eg: Metals : Metals

Ni, Mg, Cu: Nb, Zn, Zr

3. Mention any two chemical properties of metallic glasses. (A.U. Covai June 2010)

Two chemical properties of metallic glasses are

a) They are highly resistant to corrosion due to the formation of protective oxide film in Chromium containing glasses.
b) They are highly reactive and stable.

4. What are the advantages of using metallic glasses as transformer core materials? (A.U. Covai June 2009, A.U. Trichy June 2009)

The advantages of using metallic glasses as transformer core materials are

a) Metallic glasses are Ferro-magnetic.
b) They possess low coercivity and low magnetic losses.
c) They have high permeability and saturation magnetization.
d) Power transformers made by metallic glasses are smaller in size and efficient in their performance.

5. Mention few applications of metallic glasses. (A.U. Trichy June 2010, A.U. Chennai Dec 2005)

The followings are the applications of metallic glasses:

a) Core materials in power distribution transformers.
b) Magnetic shielding materials, magnetic sensors, recording heads.
c) It is used in microsurgical instruments, flow controls etc.,

d) Used to make razor blades.
e) Active material in rewritable compact disc.

6. What do you understand by the term quenching? (A.U. Chennai June 2014, A.U Chennai April 2015)

Quenching is one of the important techniques to synthesis metallic glasses. Quenching means extremely rapid cooling. At high temperature, atoms freely move in the materials. During rapid cooling, atoms get arranged in an irregular pattern which results in the formation of metallic glasses.

7. Why metallic glasses are used as transformer core materials? (A.U Chennai Nov 2015)

The metallic glasses are used as transformer core materials because

a) Metallic glasses are ferromagnetic. They posses low magnetic losses, high permeability and saturation magnetization with low coercivity.
b) They also have extreme mechanical hardness and excellent initial permeability.

8. What are Shape Memory Alloys? (A.U. Covai Dec 2010, A.U. Trichy June 2010, A. U Chennai June 2006)

When the material is heated above the transformation temperature, then there will be some change in the crystal structure, which causes the material to return to its original structure. Such material is called shape memory alloy.

9. Explain Shape Memory Effect. (A.U. Chennai June 2010, A.U Chennai Dec 2016)

At lower temperature the SMA will be in Martensite structure and when it is heated it will change its shape to Austenite structure and while cooling it will again return to martensite form. This effect is called shape memory alloy.

10. Write the properties of Shape Memory alloys (Ni-Ti Alloy). (A.U. Chennai 2009)

The properties of Shape Memory alloys are

a) It has high corrosion resistance &thermal stability.
b) It is more flexible.
c) It has high melting point.
d) It has high shape memory strain (8.5%).

11. Why Ni-Ti (Nitinol) alloy is difficult to make? (A.U. Covai June 2010)

Ni-Ti (Nitinol) alloy is difficult to make because

a) Melting temperature is high.

b) Machine milling, welding and soldering is very difficult.

12. Mention some of the applications of Shape memory alloys. (A.U Chennai Nov 2015 R2008)

The applications of Shape memory alloys are

a) It act as actuators and sensors.
b) Its uses to produce twist on the Helicopter blades.
c) It used in orthopedic devices.

13. What are ceramic materials?

Most of the ceramics are compounds of metallic and non-metallic elements. The crystal structure of ceramics is more complex because at least two elements are involved in making a ceramic compound. Ceramics can be used at low as well as high temperatures.

Ceramic materials are obtained by firing them at high temperatures. Traditional ceramics are clay products like bricks, tiles and porcelain. China ceramics are obtained by firing clay products.

14. List out the classification of Ceramics.

Ceramics are classified as

a) Natural or manufactured

b) Functional Classification

c) Structural Classification

d) Traditional ceramic materials and

e) Engineering ceramic materials

15. Classify the ceramics based on Structural Classification .

The ceramics are classified as

a) Crystalline Ceramics : Single phase like MgO or multiphase from the MgO to Al_2O_3 binary system.

b) Non-Crystalline Ceramics : Natural and synthetic inorganic glasses e.g., window glass.

c) Glass-bonded Ceramics : Fired clay products - Crystalline phases are held in glassy matrix.

d) Cement : Crystalline or Crystalline and non-Crystalline phases.

16. Mention the applications of ceramic materials.

The applications of ceramic materials are

a) The ceramics are hard, strong and dense.

b) They have high resistance to the reaction of chemicals and to the weathering.

c) Possess a high compression strength compared with tension.

d) They have high fusion points.

e) They offer excellent dielectric properties.

f) They are good thermal insulators.

17. What are natural ceramics materials and traditional ceramic materials?

Ceramics can be natural or manufactured Natural Ceramics

The most frequently used, naturally occuring ceramics are:Silica (SiO_2) , Silicates and Clay minerals.

Traditional ceramics are made from three basic components: clay, silica, and feldspar. Example : glasses, tiles, bricks and porcelain.

18. What are engineering ceramics materials and composite materials?

Engineering ceramics are mainly pure compounds or oxides,carbides or nitrides of pure compounds. Some of the important engineering ceramics are alumina (Al_2O_3), silicon nitride (Si_3N_4), Silicon Carbide (SiC) and Zirconia (ZrO_2).

Composite materials, are a combination of two or more materials that are different in chemical composition. Composite materials can be a combination of various materials, such as plastics, metals, fibers or ceramics.

19. How composite materials are classified?

Based on the reinforcement techniques, composites are classified as: (a) Fiber-reinforced (b) Structural (c) Particle-reinforced.

20. What is the function of matrix materials?

In composites, the matrix phase serves important functions. First it binds the reinforcement (fibers) together. It acts as a medium and transmits and distributes the external loads to the fibers.

21. What is meant Fiber - Reinforced ?

Fiber-reinforced composites consist of thin fibers of a material, which are suspended in a matrix of another material. Matrix is the medium or the substance in which the fibers are suspended.

22. List out the limitation of composites.

The limitation of composites are

a) Polymeric composites cannot be used for high temperature application.

b) Cost of composites is somewhat higher than may conventional materials.

23. Glass is popular as a fiber reinforcement material. Why?

Glass is popular as a fiber reinforcement material, because

a) It is easily drawn into high strength fibers from the molten state.

b) It is readily available and may be fabricated into a glass-reinforced plastic economically using a wide variety of composite-manufacturing techniques.

c) As a fiber, it is relatively strong, and when embedded in a plastic matrix, it produces a composite having a very good specific strength.

d) When coupled with various plastics, it possesses a chemical inertness that renders the composite useful in a variety of corrosive environments.

24. Mention the processing steps of fiber reinforced Plastics.

The processing steps of fiber reinforced Plastics are

a) Mixing the resin and activator.

b) Placing the reinforcement in the mould.

c) Impregnating reinforcement with resin.

d) Dispensing resin into the mould.

e) Curing.

25.Write short note on Filament winding.

Filament winding is employed for the production of simple hollow shapes and is particularly suitable for pressure vessels. The molding of the component is done on a male former, giving a molded surface on the inside.

26. What are biomaterials?

The materials which are used for structural applications in the field of medicine are known as Biomaterials. These materials are used to make devices to replace damaged or diseased body parts in human and animal bodies.

27. List out the types of biomaterials and their applications.

S.No.	Name of the material	Applications
1	Stainless steel (Wrought bar).	To make bone screws and stems of implanted prosthesis.
2	Cobalt based alloy (with titanium and stainless steel).	Used in implant devices.
3	Porous ceramics.	Used in mitral valve prosthesis.
4	Porous high density polyethylene.	Used in dental implants.
5	Acrylic resins.	Used as bone cements.

28. Define sensor.

A sensor is a converter that measures a physical quantity and converts it into a signal which can be read by an observer or by an (mostly electronic) instrument.

29. What is Chemical sensor and biosensor??

A chemical sensor is a analytical device that can provide information about the chemical composition of its environment, that is, a liquid or a gas phase. The information is provided in the form of a measurable physical signal that is correlated with the concentration of a certain chemical species.

In biomedicine and biotechnology, sensors which detect analytes respond to a biological component, such as cells, protein,nucleic acid or biomimetic polymers, are called biosensors.

30. What is hydroxylapatite and silicone?

Hydroxylapatite also called hydroxyapatite (HA), is a naturally occurring mineral form of calcium apatite with the formula $Ca_5 (PO_4)_3 (OH)$, but is usually written $Ca_{10} (PO_4)_6 (OH)_2$ to denote that the crystal unit cell comprises two entities. The OH^- ion can be replaced by fluoride,

chloride or carbonate, producing fluorapatite or chlorapatite etc.It crystallizes in the hexagonal crystal system.

Silicones are inert, synthetic compounds with a variety of forms and uses. Typically heat-resistant and rubber-like, they are used in sealants, adhesives, lubricants, medical applications, cooking utensils, and insulation. Silicones are polymers that include silicon together with carbon, hydrogen, oxygen, and sometimes other elements. Some common forms include silicone oil, silicone grease, silicone rubber, silicone resin, and silicone caulk.