ENGINEERING PHYSICS – I

PART – A IMPORTANT QUESTIONS

UNIT – I CRYSTAL PHYSICS

1. List the different types of point defects.

(i) Vacancy
(ii) Schottky defect
(iii) Frenkel defect
(iv) Substitutional impurities
(v) Interstitial impurities.

2. What are the co-ordination numbers for SC, BCC & FCC Structures?

Co-ordination number is the number of nearest neighbouring atoms to a particular atom. The co-ordination number for SC is 6, for BCC it is 8 and for FCC it is 12.

3. A crystal plane cut at 3a, 4b and 2c distances along the crystallographic axes. Find the Miller Indices of the plane.

Given data : Intercepts = 3a: 4b : 2c

Solution

Step (i) : Co-efficients of intercepts = 3: 4: 2

Step (ii) : Reciprocal of intercepts $= \frac{1}{3} : \frac{1}{4} : \frac{1}{2}$

Step (iii) : LCM = 12

Step (iv) : Multiplying by LCM with the reciprocals

$$12\times\frac{1}{3} \quad : \quad 12\times\frac{1}{4} \quad : \quad 12\times\frac{1}{2}$$

We have 4 3 6

Miller Indices = (4 3 6)

4. Define packing factor (or) packing density (or) density of packing. Give its unit.

It is defined as the ratio of the volume of atoms per unit cell to the total volue occupied by the unit cell.

$$APF = \frac{No.of\ atoms\ present\ in\ a\ unit\ cell \times Volume\ of\ one\ atom}{Volume\ of\ the\ unit\ cell}$$

Since Atomic Packing factor is the ratio, it does not have any unit.

5. Define unit cell.

It is the smallest geometrical structure of a solid from the entire crystal structure can be constructed by repetition in three dimensions.

6. What are Miller Indices?

Miller Indices are the smallest possible integers which have the same ratios as the reciprocals of the intercepts of the plane concerned on the three axis.

7. What is meant by primitive and Non-primitive Cell? Give an example.

A primitive cell is the simplest type of unit cell which contains only one lattice point per unit cell.

Example : Simple Cubic (SC).

If there are more than one lattice point in an unit cell, it is called Non-Primitive cell.

Example: BCC & FCC.

8. What is meant by loosely packed structure? Give an example.

The loosely packed structure has the packing factor less than 0.74. That is, in which more vacant site is available.

Example: Simple cubic polonium & body centered sodium.

9. What is meant by closely packed structure? Give an example.

Closely packed structure has the highest packing factor of 0.74. Here the atoms are closely packed leaving a small space as vacant site in the crystal.

Example: Face centered cubic copper & hexagonal closely packed magnesium.

10. Write the parameters for Triclinic crystal.

$a \neq b \neq c$

$\alpha \neq \beta \neq \gamma \neq 90^0$.

11. Calculate the value of d-spacing for (100) planes in a rock salt crystal of a = 2.814 Å.

Given: a = 2.814 Å
h = 1
k = 0
l = 0

$$d-spacing\ (or)\ d_{hkl} = \frac{a}{\sqrt{h^2+k^2+l^2}}$$

$$d-spacing\ (or)\ d_{100} = \frac{2.814\times10^{-10}}{\sqrt{1^2+0^2+0^2}}$$

d = 2.814 Å

12. State the values of co-ordination number for HCP structure and diamond structure.

Co-ordination number for HCP = 12.

Co-ordination number for diamond = 4.

13. The lattice constant for a FCC structure is 4.938 Å. Calculate interplanar spacing for (220) planes.

Given: a = 4.938 Å
h = 2
k = 2
l = 0

$$d-spacing\ (or)\ d_{hkl} = \frac{a}{\sqrt{h^2+k^2+l^2}}$$

$$d-spacing\ (or)\ d_{220} = \frac{4.938\times10^{-10}}{\sqrt{2^2+2^2+0^2}}$$

$$d-spacing\ (or)\ d_{220} = \frac{4.938\times10^{-10}}{2\sqrt{2}}$$

d = 1.7458 Å

14. What are Bravais lattices?

The 14 possible ways of arranging points in space lattice such that all the lattice points have exactly the same surroundings. These 14 lattices are called the Bravais lattices.

15. Which crystal structure is having least co-ordination number? Give an example.

Diamond has the least co-ordination number, i.e., Four.

16. A unit cell has the dimensions a = b = c = 4.74 Å and α ≠ β ≠ γ ≠ 60^0, what is the crystal structure?

For a = b = c = 4.74 Å and α ≠ β ≠ γ ≠ 60^0, the crystal structure is Trigonal (or) Rhombohedral.

17. Defects in crystals are not always harmful. Why?

Doping in pure semiconductor increases their electrical conductivity and given boundaries increases the mechanical strength of the material. Hence, the crystals are not always harmful.

UNIT – II PROPERTIES OF MATTER AND THERMAL PHYSICS

1. Explain neutral axis (or) How are the various filaments of a beam affected when the beam is loaded?

The middle layer (or) filament of a beam which remains unaltered even with the presence of load on the beam is called neutral axis.Filaments which are lying above it are elongated and those are lying below it are compressed.

2.What are the effects of hammering and annealing on elasticity of a material?

While being hammered or rolled,crystal grains break into smaller units resulting in increase of their elastic properties.While annealing constituent crystals are uniformly oriented and form larger crystal grains,Which results in decrease in their elastic properties.

3.Mention the factors affecting the elasticity of a material.

1.Temperature
2.Impurities
3.Hammering,Rolling and Annealing
4.Stress

4.Explain bending moment of beam.

The Moment of the couple due to the elastic reactions which balances the external Couple due to the applied load is called the bending moment.

5.Define stress and strain and write down their units.

Stress: Stress is defined as the restoring force per unit area which brings back the Body to its original state from the deformed state.**Unit for stress:** N/m2.

Strain: Strain is defined as the change in dimension produced by the external force on the body.It can also be defined as the ratio of the change in dimension to the original dimension.**No Unit.**

(i.e) Strain= Change in dimension

6.What do you infer from Stress-Strain diagram.

From the Stress-Strain diagram,.we can infer the following points.

1.The Stress is directly proportional to the strain,within elastic limit.
2.It distinguishes the elastic and plastic limit of a material.
3.It determines the ultimate strength of the material.
4.The stress-Strain diagram also helps us to distinguish the material based on the properties such as ductility and brittleness.

7.How do temperature and impurity in a material affect the elasticity of the materials?

(1)Effect of temperature: The rise in temperature decreases elasticity and vice versa.

Example: The carbon filament becomes plastic at higher temperatures.

(2)Effect of impurities: The addition of impurities produces variation in the elastic property of the materials.The increase and decrease in elasticity depends on the type of impurity added to it.

Example: Whwn potassium is added to gold,the elasticity property of gold increases.

8.Explain the advantages of I-Shape girder.

I-Shape griders are made by the reducing the area of the neutral axis.
Hence it has the following advantages.

(1)More stability
(2)More Strength and
(3)High durability

Also,I-shape girders are manufactured by using less amount of raw materials.

9.What are the basic entites responsible for thermal condition of a solid?

(1)Area of cross section (A)
(2)Temperature difference between the hot and cold layers of the solid (01-02)
(3)Time of conduction(t)
(4)Thickness of the solid(x)

10.Define Coefficient of thermal conductivity.

The Coefficient of thermal conductivity is defined as the amount of heat conducted per second normally across the unit area of croiss section,maintained at unit temperature gradient.

$$(i.e)\ K=\frac{Qx}{A(01-02)t}\quad Wm\text{-}1k\text{-}1$$

11.Define Newton's Law of Cooling.

Newtons law: The rate of loss of heat of a body is directly proportional to the temperature difference between the body and its surrounding,of same nature.

UNIT – III QUANTUM PHYSICS

1. **Mention the physical significance of wave function of matter waves (or) de Broglie waves.**
   (i) A variable quantity which characterizes waves is known as wave function.
   (ii) It relates the particle and the wave statistically.
   (iii) It gives the information about the particle behavior.
   (iv) It is a complex quantity.
   (v) Ψ represents the probability density of the particle which is real and positive.

2. **What are meant by a degenerate state and Non-degenerate state?**
   For various combinations of quantum numbers, if we get same eigen value but different eigen functions, it is called degenerate state.
   For various combinations of quantum numbers, if we get same eigen value but same eigen functions, it is called Non-degenerate state.

3. **What is Compton wavelength? Calculate its value**.
   The shift in wavelength corresponding to the scattering angle of 90^0 is called Compton wavelength.

$$Compton\ Shift\ \Delta\lambda = \frac{h}{m_0 c}(1-\cos\theta)$$

When $\theta = 90^0$, $\cos\theta = 0$

$$Compton\ Shift\ \Delta\lambda = \frac{h}{m_0 c}$$

$$Compton\ Shift\ \Delta\lambda = \frac{6.625\times10^{-34}}{(9.11\times10^{-31})\times(3\times10^5)}$$

$$\boxed{\Delta\lambda = 0.02424\ \text{Å}}$$

4. **State Planck's quantum theory (or) State Planck's hypothesis (or) What are the postulates of Planck's quantum theory? (or) What are the assumptions of quantum theory of black body radiation? (or) Give the special features of Quantum theory.**

   (i) The electrons in the black body are assumed as simple harmonic oscillators.
   (ii) The oscillators will not emit energy continuously.
   (iii) The emit radiation in terms of quantas of magnitude 'hυ', discretely.
   i.e. E = nhυ, where n = 0, 1, 2, 3, …..

5. **What is the principle electron microscopy?**
   In an electron microscope, a stream of electrons are passed through the object and the electrons which carry the information about the object are focused by electric and magnetic lenses (or) electromagnetic lenses.

6. **Define Compton Effect.**

When a photon of energy 'hυ' collides with a scattering element, the scattered beam has two components, i.e., one has the same frequency (or) wavelength as that of the incident radiation and the other has lower frequency (or) higher wavelength compared to incident radiation. This effect is called Compton Effect.

7. State Wien's displacement law. Give its limitation.

The product of wavelength (λ_m) of maximum energy emitted and the absolute temperature (T) is a constant.

$\lambda_m T$ = Constant.

Limitation: It holds good only for shorter wavelength.

8. State Rayleigh-Jeans law. Give its limitation.

The energy is directly proportional to the absolute temperature and is inversely proportional to the fourth power of the wavelength.

$$E_\lambda \alpha \frac{T}{\lambda^4}$$

Limitation: It holds good only for longer wavelength.

9. State de-Broglie hypothesis (or) Explain the concept of wave nature (or) What is meant by matter waves? (or) Give the origin of concept of matter waves.

The light exhibits the dual nature. It can behave as a particle and the wave. de Broglie suggested that an electron which is a particle can also behave as a wave and exhibits the dual nature.

Thus the waves associated with a material particle (electron) are called as matter waves.

If 'v' is the velocity and 'm' is the mass of the particle,

$$de\ \ Broglie\ wavelength\ \lambda = \frac{h}{mv}$$

10. What is black body and what are its characteristics?

A perfect black body is the one which absorbs and also emits the radiations completely.

There is no black body in nature. We have to coat the black colour over the inner surface to make a black body.

Black body is said to be a perfect absorber, since it absorbs all the wavelengths of the incident radiation. The black body is the perfect radiator because it radiates the entire wavelength absorbed by it. This phenomenon is called black body radiation.

11. For a free particle moving within a one dimensional potential box, the ground state energy cannot be zero. Why?

For a free particle moving within a one dimensional potential box, when n = 0, the wave function is zero for all values of x, i.e., it is zero even within the potential box. This would mean that the particle is not present within the box. Therefore the state with n = 0 is not allowed. As energy is proportional to n^2, the ground state energy cannot be zero since n = 0 is not allowed.

12. Bring out the differences between Scanning Electron Microscope (SEM) and Transmission Electron Microscope (TEM).

SEM	TEM
1. Scattered electrons are used to form the image.	1. Transmitted electrons are used to form the image.
2. Scanning of electron beam on the specimen is required. Hence scanning circuit is used.	2. Scanning is not required and hence scanning circuit is not used.
3. Even a thick or specimens can be analyzed.	3. Very thin sample has to be used.
4. Very good contrast.	4. Contrast is poor.
5. Preparation of sample is more complicated.	5. Preparation of sample to analyze is easy.

UNIT – IV ULTRASONICS AND ACOUSTICS

1. **Mention any four properties of Ultrasonic waves.**
   (a) They are highly energetic.
   (b) They travel through longer distances.
   (c) They are reflected, refracted and absorbed similar to ordinary sound waves.
   (d) When ultrasonic waves are passed through the liquid, it behaves as an acoustical grating element.
   (e) It produces heating effect.

2. **State Magnetostriction Principle.**
   Magnetostriction effect is the principle of producing ultrasonic waves by the Magnetostriction oscillator. When an alternating magnetic field is applied to a ferromagnetic rod such as iron, nickel, the rod is thrown into longitudinal vibrations. When the frequency of the rod is equal to the natural frequency of vibration, resonance occurs. Thus ultrasonic waves are produced.

3. **What is cavitation? Mention its use (or) Briefly outline the emulsification using ultrasonic waves.**
   Cavitation is the process of creation and collapse of bubbles due to the principle of negative local pressure created inside the bubble. Thus it produces enormous amount of heat and pressure.
   Uses: (i) It is used to produce shock waves.
   (ii) It is used to produce the temperature in liquids.

4. **What is Piezo-electric effect? (or) What is direct Piezo-electric effect?**
   When pressure or mechanical force is applied along one pair of opposite faces of a quartz crystal, then equal and opposite charges are produced along the another pair of opposite faces of the crystal. This is called Piezo-electric effect.

5. **What is inverse Piezo-electric effect?**
   If an electric field is applied to one pair of opposite faces of a quartz crystal, alternative mechanical expansions and contractions are produced across the another pair of opposite faces of the crystal. This is called inverse Piezo-electric effect.

6. **What is sonogram? Mention its application.**
   Sonogram is a technique which is used to record the sounds produced due to the pumping action of the heart using ultrasonics. It also provides the information on heart ratio, rhythmicity, blood pumping, valve action etc.
7. **How is acoustic grating is formed?**
   When ultrasonic waves are passed through the liquid like kerosene, due to variation in pressure, the liquid act as acoustical grating. Now monochromatic light is

passed through this acoustical grating, it produces different orders of spectrum due to diffraction. Using diffraction condition we can find the velocity of ultrasonics.

8. What is the principle of SONAR in ultrasonics? Mention two applications of it.

SONAR is a device which stands for **SO**und **NA**vigation and **R**anging. It is based on the principle of **ECHO-SOUNDING** of ultrasonic waves. It is acoustical technique for locating the objects like submarine or icebergs in sea by transmitting a high frequency sound pulse and receiving it from the object.

Applications: (i) It is used to locate the objects at the bottom of the sea.

(ii) It is used to find the depth of the sea.

(iii) It is used for seismic (earth quake) survey.

9. How are ultrasonic waves used to measure the depth of sea?

Echo-sounding is the principle used to find the depth of the sea. A beam of ultrasonic waves is transmitted towards the bottom of the sea and the reflected signal is received.

The time interval between transmitted and received signal is noted and let it be 't'. If 'v' is the velocity of the ultrasonics,

$$Velocity = \frac{Dis\tan ce\ travelled}{Time\ taken}$$

Here draw the figure from the book. Page number 1.14

$$v = PR + \frac{RQ}{t}$$

$$v = \frac{2RO\ (approx)}{t}$$

$$RO = Depth\ of\ \ sea = \frac{vt}{2}$$

10. How are ultrasonic waves detected by thermal method?

When the ultrasonic waves are passed through the platinum wire connected to a Wheatstone's bridge, the temperature of wire changes which in turn changes the resistance of the platinum wire. Hence Wheatstone's Bridge goes to unbalanced position. With respect to the balancing position of the Wheatstone's bridge, ultrasonic waves are detected.

11. Mention the uses of ultrasound in clinical medicine (or) Mention the medical applications of ultrasonics.

(i) Ultrasonic waves are used for detecting tumours and other defects in human body.

(ii) Ultrasonic waves are used to remove kidney stones and brain tumours without any loss of blood.

(iii) Ultrasonic therapy is used to treat disease like neuralgic and rheumatic pains etc.

12. Why ultrasonic frequencies greater than 3 MHz cannot be produced by magnetostriction method?

In Magnetostriction method, the frequency is inversely proportional to the length of the rod. The frequency can be increased only by decreasing the length of the rod to a greater instant. It is practically impossible. Also, it has to be noted that the ambient temperature alters the magnetization of the rod and in turn will affect the elastic properties. Hence ultrasonic frequencies greater than 3 MHz cannot be produced by magnetostriction method.

13. Define *A*-*Scan* display in ultrasonics.

A scan is an amplitude mode display. It gives one dimensional information about the specimen. It is used to detect the position and size of the flaws with the help of change in its amplitude.

14. List out the applications of ultrasonic waves.

(i) Measurement of depth of the sea.
(ii) Detection of flaws in materials.
(iii) Cutting, drilling, welding and grinding.
(iv) Speed up the chemical reaction (Coagulation)
(v) Relieving the body pains
(vi) Cleaning and drying the clothes.

15. List out the engineering/ industrial applications of ultrasonics.

(i) By oscillating the glass rod with ultrasonic frequency, holes can be drilled in the hard steel plates.
(ii) They are used in welding and cutting.
(iii) They are used in cleaning cloths and tiny parts of watch.
(iv) They are used to form alloys of uniform compositions.

16. Can we use a copper rod in a Magnetostriction generator? Why?

No, copper rod cannot used to produce ultrasonic waves in Magnetostriction generator. Because it is not a Ferromagnetic material.

17. Give the principle used in measurement of velocity of blood flow.

When ultrasonic wave strikes the blood vessel, the beam is reflected by particles of blood. Depending upon the velocity of blood, the reflected beam is Doppler shift. Therefore by the principle of double Doppler effect, the velocity of blood flow can be calculated.

18. An ultrasound pulse sent by a source in sea is reflected by a submerged target at a distance 597.50 cm and reaches the source after 0.83 seconds. Find the velocity of sound in sea water.

Given:

Distance (d) = 597.50 cm
Time taken (t) = 0.83 sec.

Formula:

$$Velocity\ (v) = \frac{2d}{t}$$

$$Velocity\ (v) = \frac{2 \times 597.50}{0.83}$$

$$Velocity\ (v) = \frac{1195.00}{0.83}$$

$$\boxed{Velocity\ (v) = 1439.75\ m/s}$$

19. A quartz crystal with a thickness of 0.5 mm and a density of 2650 kg/m^3 vibrates longitudinally producing ultrasonic waves. Find the fundamental frequency of vibration, if the Young's modulus of quartz is 7.9 x 10^{10} Nm^{-2}.

Given: Thickness (t) = 0.5 x 10-3 m
Density (ρ) = 2650 kg/m^3
Young's modulus (E) = 7.9 x 10^{10} Nm^{-2}

Formula:

$$Frequency\ (f) = \frac{P}{2t}\sqrt{\frac{E}{\rho}}$$

For fundamental mode P = 1

$$Frequency\ (f) = \frac{1}{2t}\sqrt{\frac{E}{\rho}}$$

$$Frequency\ (f) = \frac{1}{2 \times 0.5 \times 10^{-3}}\sqrt{\frac{7.9\,10^{10}}{2650}}$$

$$Frequency\ (f) = \frac{1 \times 5459.97}{1 \times 10^{-3}}$$

$$\boxed{Fundamental\ \ frequency\ (f) = 5.45997\ MHz}$$

UNIT – V PHOTONICS AND FIBRE OPTICS

1. **State the properties of laser beam (or) fundamental characteristics of lasers (or) Name the properties of laser which are making it suitable for industrial applications.**
   (i) The laser beam is highly directional.
   (ii) It has high intensity.
   (iii) It has purely monochromatic.
   (iv) It has coherence.

2. **What do you mean by population inversion?**
   In general, the number of atoms in the ground state will be more than that of the atoms in the excited state. This is called usual population.
   The state of achieving more number of atoms in the excited state than that of the atoms in the ground state is called population inversion.

3. **Define metastable state.**
   It is the state for which the life time is more than the excited state, i.e., it is the more stable state which lies between the excited state and the lower state.

4. **Why is population inversion necessary for laser action? (or) Explain the need of population inversion in the production of lasers.**
   When population inversion is achieved, the majority of atoms are in the excited state. So the absorption coefficient will be negative. The negative absorption coefficient causes the amplification of the incident beam by stimulated emission. Thus the laser beam is produced. Hence, population inversion is a must for the production of laser beam.

5. **What are Einstein's coefficients?**
   The Einstein's coefficients A and B accounts for spontaneous and stimulated emission / absorption probabilities of light by a system of particles. It also explains the importance of metasatble states.

6. **Define Active medium and Active center.**
   The medium in which the population inversion takes place is called as active medium.
   The material in which the atoms are raised to excited state to achieve population inversion is called as active center.

7. **What is meant by optical resonator? (or) resonance cavity?**
   An optical resonator is a feedback system which consists of an active medium kept in between a 100% mirror and a partial mirror. Here the intensity of light produced in the active medium is increased by making the light to bounce back and forth between the mirrors. Finally the laser beam comes through the partial mirror.

8. **Can a two level system be used for the production of laser? Why?**
   No, two level system cannot be used for the production of laser. Because for population inversion to be achieved at least three levels are required.

9. List out the differences between a hologram and a photograph (or) How does Holography differ from Photography?

Photograph	Hologram
1. Ordinary light is used.	1. Laser light is used.
2. The variation of amplitude alone is recorded.	2. The distribution of amplitude and phase is recorded.
3. It gives 2D picture.	3. It gives 3D picture.
4. Lens is used.	4. No lens is used.

10. What are the two types of transitions that are possible in a CO_2 gas laser?

(i) Transition from asymmetric mode $[00^01]$ to bending mode $[02^00]$ will emit laser of wavelength 9.6 μm.

(ii) Transition from asymmetric mode $[00^01]$ to symmetric mode $[10^00]$ will emit laser of wavelength 10.6 μm.

11. What are the roles played by N_2 and He in CO_2 laser? (or) What are the functions of N_2 and He in CO_2 laser?

In CO_2 laser, the nitrogen (N_2) helps to increase the population of atoms in the upper level of CO_2.

Helium (He) helps to depopulate the atoms in the lower level of CO_2 and to cool the discharge tube.

12. What is the role played by He in He-Ne laser? (or) What is the function of He in He-Ne laser?

In He-Ne laser, Helium helps to increase the population of atoms from lower level to upper level, thereby produces population inversion.

13. What is stimulated emission of radiation?

An atom in the excited state is induced to return to ground state thereby resulting in two in photons of same frequency and energy is called as stimulated emission.

14. List out the conditions to achieve laser action.

(i) Population inversion should be achieved.

(ii) Stimulated emission should be predominant over spontaneous emission.

15. Mention the different types of pumping methods in Lasers (or) what are the different methods of achieving population inversion?

(i) Optical pumping

(ii) Direct electron excitation

(iii) Inelastic atom-atom collision

(iv) Direct conversion

(v) Chemical process

16. Define holography.

Holography deals with image construction by means of interference techniques without using lenses. Here the distribution of amplitude and phase is recorded in 3D manner so as to get complete information of the object to be photographed.

17. Distinguish between spontaneous emission and stimulated emission.

Spontaneous emission	Stimulated emission
1. The atom in the excited state returns to ground state without any external triggering.	1. The atom in the excited state returns to ground state by external triggering.
2. Emitted photon travels in random direction.	2. Emitted photon travels in a particular direction.
3. The radiation is less intense and incoherent.	3. The radiation is highly intense, monochromatic and coherent.
4. The photons are not in phase.	4. The photons are in phase.
5. This process is a key factor for ordinary light emission.	5. This process is a key factor for laser operation.

18. List out the applications of lasers in Engineering.

(i) High power lasers are useful to blast holes in diamonds and hard steel.
(ii) They are used to test the presence of pores, cracks, blow holes etc. in the materials
(iii) They are used for welding and cutting.

19. What is the principle of semiconductor laser?

The electrons in the conduction band combines with a hole in the valence band and hence the recombination of electron and hole produces energy in the form of light. This photon, in turn may induce another electron in the conduction band to valence band and thereby stimulate the emission of another photon.

20. Distinguish between homojunction and heterojunction semiconductor lasers (or) What are the advantages of heterojunction semiconductor laser to homojunction semiconductor laser?

Homojunction laser	Heterojunction laser
1. Homojunction laser is made by a single crystalline material.	1. Heterojunction laser is made by different crystalline material.
2. Power output is low.	2. Power output is high.
3. Pulsed output (Sometimes continuous)	3. Continuous output.

4. It has high threshold current density.	4. It has low threshold current density.
5. Cost is less.	5. Cost is more.
6. Life time is less.	6. Life time is more.

21. What are the advantages of Nd:YAG laser?

(i) It has lower excitation threshold.

(ii) Since it has a higher thermal conductivity than Ruby and other solid state lasers, it lends itself for generation of laser pulses at a higher pulse repetition rate or a quasi continuous wave operation.

(iii) Its efficiency is relatively higher.

22. What is meant by pumping?

Naturally, the population inversion is achieved only at negative temperature which is impossible. Hence the process by which population inversion is achieved by artificial means is called pumping.

23. What is splicing? Mention two types of splicing.

Splicing is the technique used to connect the fibers permanently. In this technique, two fibers can be joined with the help of elastometer or four rod splices using an adhesive or matching gel.

Types: (i) Mechanical Splices

(ii) Fusion Splices

24. What is the basic principle of fiber optic communication?

Total internal reflection is the basic principle of fiber optic communication system.

Principle: When light travels from a denser to a rarer medium, at a particular angle of incidence called critical angle, the ray emerges along the surface of separation. When angle of incidence exceeds the critical angle, the incident ray is reflected in the same medium and this phenomenon is called total internal reflection.

25. Distinguish between step index fiber and graded index fiber.

Step Index Fiber	Graded Index fiber
1. The difference in refractive indices between the core and cladding is obtained in a single step and hence called as step index fiber.	1. The difference in refractive indices between the core and cladding gradually increases from centre to interface and hence called graded index fiber.
2. The light propagation in the form of meridional rays.	2. The light propagation in the form of skew rays.
	3. The light rays do not cross the fiber

3. The light rays pass through the fiber axis. 4. It follows a zig-zag path of light propagation. 5. It has low bandwidth. 6. Distortion is more.	axis. 4. It follows a helical path of light propagation. 5. It has high bandwidth. 6. Distortion is very less.

26. What are active and passive sensors?

In active sensors (or) intrinsic sensors, the physical parameter to be sensed directly acts on the fiber itself to produce the changes in the transmission characteristics.

In passive sensors (or) extrinsic sensors, separate sensing element will be used and the fiber will act as a guiding media to the sensors.

27. What is called mode of propagation in optical fibers?

Mode of propagation represents the number of possible directions or path of propagation of light through the optical fibers. When single ray of light propagate through a path, then it is called single mode and when many rays propagate through different directions, it is called multimode.

28. What is the role of cladding in optical fiber?

An optical fiber consists of core which is surrounded by cladding. Here the role of cladding is to make the light to suffer total internal reflection inside the fiber, satisfying the condition that the light should travel from denser medium to rarer medium.

29. Mention the properties of detectors used in the fiber optic communication.

(i) Ability to convert optical signal into electrical signal
(ii) Fast response time
(iii) Zero dark current
(iv) Cost effective

30. What are the ways in which an optical fiber is categorized? (or) How are fibers classified?

Optical fibers are categorized based on (i) material (ii) Number of Modes (iii) Refractive index profile

Based on material	(a) Glass Fiber (b) Plastic Fiber
Based on Number of Modes	(a) Single mode fiber (b) Multi mode fiber
Based on Refractive index profile	(a) Step index fiber

(b) Graded index fiber

31. Define Numerical Aperture.

Numerical Aperture (NA) is defined as the sine of the acceptance angle. If n1 and n2 are the refractive index of the core and cladding respectively,

$$NA = Sin\, i_m = \sqrt{n_1^2 - n_2^2}$$

It is a measure of the amount of light that can be accepted by a fiber.

32. Write any two major advantages of optical fiber communication over other conventional communication systems.

(i) Optical communication can be made even in the absence of electricity.
(ii) The optical signals are not affected by any electrical signals or lightning.
(iii) Optical fiber communication is free from Electromagnetic interference (EMI).
(iv) This is suitable to any environmental conditions.
(v) Easy maintenance, longer life, economical and high quality optical signal transmission.

33. Mention any four advantages of optical fiber (or) features of optical fiber.

(i) It is light in weight.
(ii) It is smaller in size.
(iii) It is flexible and it can bend to any position.
(iv) It is non-conductive, non-radiative and non-inductive.
(v) There is no short circuiting.
(vi) There is no internal noise / cross talks.
(vii) It can withstand any range of temperature.
(viii) No need to ground and no voltage problem occur.

34. What is step index fiber?

The difference in refractive indices between the core and cladding is obtained in a single step and hence called as step index fiber.

35. What is graded index fiber?

The difference in refractive indices between the core and cladding gradually increases from centre to interface and hence called graded index fiber.

36. List the conditions to be satisfied for total internal reflection.

(i) Light should travel from denser medium to rarer medium.
(ii) The angle of incidence (ϕ) on core should be greater than the critical angle (ϕ_c).

i.e. $\phi > \phi_c$.

(iii) The refractive index of the core (n_1) should be greater than the refractive index of the cladding (n_2).

i.e. $n_1 > n_2$

37. Give application of fiber endoscope.

(i) Fiber optic endoscopes are used in medical diagnosis.
(ii) It is used to visualize the inner organs of the body.

(iii) Fiber optic endoscopes are used in various medical fields such as cardioscopy, Laproscopy, Cytoscopy etc.

38. List out the factors that cause loss in optical fiber.

(i) During the transmission of light through optical fiber, three major losses will occur, viz., attenuation, distortion and dispersion.

(ii) Attenuation is mainly caused due to the absorption, scattering and radiation of light inside the fibers.

(iii) Distortion and dispersion occurs due to spreading of light and due to manufacturing defects.

39. Mention any four advantages of fiber optic sensors.

(i) It has no external interference

(ii) It is used in remote sensing.

(iii) Safety of data transfer.

(iv) It is small in size.

40. What are the requirements of light sources used in fiber optic communication?

(i) The light produced must be as nearly monochromatic as possible.

(ii) It must modulate the source at high speeds.

(iii) The light source should have compact size and high efficiency.

(iv) It should be reliable, durable and inexpensive.

(v) It must require very small power for its operation.

(vi) Spectral line width of the source should be as small as possible.

(vii) Can operate continuously at room temperature for many years.

(viii) It should be modulated over a wide range of frequencies.

41. A step index fiber has a numerical aperture of 0.3905 and core refractive index of 1.55. Calculate the refractive index of the cladding and acceptance angle.

Given: Numerical Aperture (NA) = 0.3905
Core refractive index (n_1) = 1055

Formula:

$$NA = \sqrt{n_1^2 - n_2^2}$$

$$n_2 = \sqrt{n_1^2 - (NA)^2}$$

$$n_2 = \sqrt{(1.55)^2 - (0.3905)^2}$$

$$n_2 = \sqrt{2.4025 - 0.15249}$$

$$n_2 = \sqrt{2.25001}$$

Re *fractive index of cladding* $n_2 = 1.5$

Acceptance Angle $i_m = Sin^{-1} NA$

$i_m = Sin^{-1} (0.3905)$

$i_m = 22.9856$

(or) $i_m = 22^0\ 59'$

(i)	**Refractive index of cladding = 1.5**
(ii)	**Acceptance Angle = 22^0 59'**