DEPARTMENT OF PHYSICS

QUESTION DATA BASE
(Common to all branches)
R2017

YEAR: I **SEMESTER : I**
SUBJECT CODE: PH8151 **SUBJECT NAME: ENGG. PHYSICS**

UNIT I
PROPERTIES OF MATTER
PART A QUESTIONS

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 (that is, heating and then cooling gradually) 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.**
   i) Temperature
   ii) Impurities
   iii) Hammering, Rolling and annealing
   iv) Stress

4. **Explain bending moment of beam.**
   The moment of the couple due to the elastic reactions (restoring couple) which balances the external couple due to 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/m^2.**
   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/ Original dimension

6. **What do you infer from Stress – Strain diagram?**
   From Stress – Strain diagram, we can infer the following points.
   (i) The Stress is directly proportional to the strain, within elastic limit.
   (ii) It distinguishes the elastic and plastic limit of a material.
   (iii) It determines the ultimate strength of the material.
   (iv) The Stress – Strain diagram also helps as to distinguish the material based on the properties such as ductility and brittleness.

7. **How do temperature and impurity in a material affect elasticity of the materials?**
   i) Effect of temperature: The rise in temperature decreases elasticity and vice versa.
   Example: The carbon filament becomes plastic at higher temperatures.
   ii) Effect of impurities: The addition of impurities produces variation in the elastic property of the materials. The increase and the decrease in elasticity depends on the type of impurity added to it.
   Example: When potassium added to gold, the elastic property of gold increases.

8. **Explain the advantage of I-Shape girder.**
   I-Shape girders are made by the reducing the area of the neutral axis. Hence it has the following advantages.
   i) More Stability.
   ii) More Strength and
   iii) High durability
   Also, I-Shape girders are manufactured by using less amount of raw material.

9. **What is Poisson's ratio?**
   Within the elastic limit, the laterial strain is proportional to the linear strain. i.e., the ratio of the lateral strain and linear strain is a constant for the given material.

10. **What is mean by twisting couple?**
    Torsional rigidity is also known as the twisting couple per unit twist. As the name suggests it is the amount of twisting couple or torque required to twist the object by one unit angle, i.e., one radian.

PART – B

1. Describe with necessary theory, the method to determine the Young's modulus of the material of a rectangular bar by uniform bending.
2. What is cantilever? Obtain the equation for the depression at the loaded end of a cantilever whose other end is fixed assuming that its own weight is not effective in bending.
3. Describe an experiment to determine the Young's modulus of the beam using bending of beams?
4. Derive an expression for the internal bending moment of a beam terms of radius of curvature?
5. A curricular and a square cantilever are made of same material and have equal area of cross-section and length. Find the ratio of their depressions for a given load.
6. i) Derive an expression for the elevation for the centre of cantilever which is loaded at both ends.
   ii) Describe an experiment to determine Young's modulus of a beam by uniform bending.
7. Derive an expression for depression at the free end of a cantilever, due to load. Describe an experiment to determine the Young's modulus of the cantilever material using this expression.
8. Give the theory of torsion pendulum and describe a method to find the moment of inertia of the disc and the rigidity modulus of the material of a wire using torsion pendulum?

UNIT II
WAVES AND OPTICS
PART A QUESTIONS

1. What is damped oscillation?

Most of the oscillations in air or in any medium are damped. When an oscillation occurs, some kind of damping force may arise due to friction of air resistance offered by the medium.

So, a part of the energy is dissipated in overcoming the resistive force. Consequently, the amplitude of oscillations decreases with time and finally becomes zero. Such oscillations are called damped oscillations

2. What is forced oscillation?

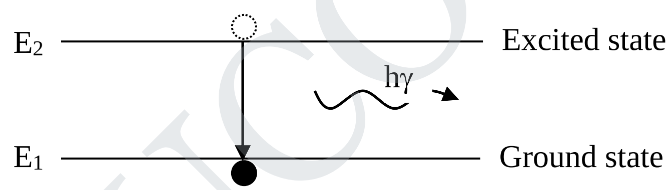
When a vibrating body is maintained in the state of oscillations by a periodic force of frequency other than its natural frequency of the body, the oscillations are called forced oscillations.

3. Define plane progressive Wave.

Progressive wave originating from a point source and propagating through an isotropic medium travel with equal velocity in all directions.

At any instant, the wave front will be spherical in nature. If the sphere of very large radius is considered, the spherical wave will approximate to a plane surface and the waves are called plane progressive waves.

4. What is spontaneous emission?

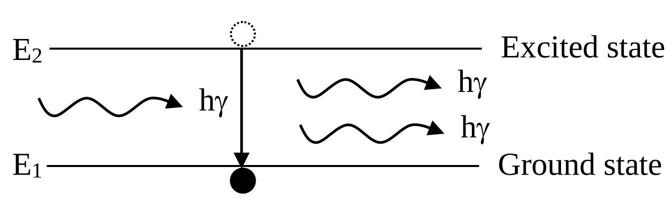


The atom in the excited state E_2 (higher energy state), returns to the ground state E_1 (lower energy state), by emitting a photon of energy hγ without the action of an external energy. Such an emission of radiation which is not triggered by an external influence is called spontaneous emission.

5. What is stimulated emission?

The process of forced emission of photons caused by the incident photons is called stimulated emission. It is also called induced emission. This process is the key factor to the operation of a laser.

6. What is pumping emission?



Pumping is the process of raising more number of atoms to excited state by artificial means is called as pumping process. There are several methods by which the population inversion (pumping) can be achieved.

7. What are the pumping methods are available?

Some of the commonly used methods are:

- Optical pumping
- Direct electron excitation or electric discharge
- Inelastic atom-atom collision method
- Direct conversion method, and
- Chemical method.

8. What is meant by population inversion and how it is achieved?

Establishment of a situation in which number of atoms in higher energy state is greater than that in lower energy state is called population inversion. For normal situation, the number of atoms N_2 i.e., population of higher energy state is much lesser than the population of lower energy state N_1, i.e., $N_1>N_2$. The phenomenon of making $N_2>N_1$ i.e., the number of atoms N_2 in higher energy state is more than the number of atoms N_1 in lower energy state is called population inversion or inverted population. Population inversion can be achieved by means of pumping action.

9. State the properties or characteristics of laser beam.

The most important features or characteristics of lasers are:

- Directionality
- High intensity
- Extraordinary monochromacity, and
- High degree of coherence

10. Distinguish between ordinary and laser beam.

S.No.	Ordinary light	Laser light
1.	In ordinary light angular spread is more	In laser beam angular spread is less
2.	They are not directional	They are highly directional
3.	It is less intense	It is highly intense
4.	It is not a coherent beam and is not inphase	It is coherent beam and is inphase
5.	The radiations are polychromatic	The radiations are non-polychromatic
6.	Examples: Sunlight, mercury vapour lamp etc.	Examples: He-Ne laser, CO_2 laser etc.

11. What are Einstein's relations or coefficients?

In Einstein's theory of spontaneous emission and stimulated emission, we have,

$$B_{21}=B_{12}$$

$$A_{21} / B_{21}=8\pi h\gamma^3/c^3$$

A_{21}, B_{12} and B_{21} are three constants known as Einstein's coefficients

12. What are the differences between stimulated and spontaneous emission of radiations?

S.No.	Stimulated emission	Spontaneous emission
1.	A atom in the excited state is induced to return to ground state, thereby resulting in two photons of same frequency and energy is called stimulated emission.	The atom in the excited state returns to ground state thereby emitting a photon, without any external force is called spontaneous emission.
2.	The emitted photons move in the same directions and is highly directional.	The emitted photons move in all directions and are random.
3.	The radiation is high intense, monochromatic and coherence.	The radiation is less intense and is incoherent.
4.	The photons are in phase i.e., there is a constant phase difference.	The photons are not in phase i.e., there is no phase relationship between them.

13. What is the principle of laser?

Due to stimulated emission, the photons multiply in each step giving rise to an intense beam of photons that are coherent and moving in the same direction. Hence, the light is amplified by stimulated emission of radiation, termed as LASER.

14. Explain metastable state.

Any atom can be excited to a higher level by the absorption of energy. Normally, excited atoms have short lifetimes (10^{-9} seconds) through spontaneous emission. In order to establish the condition of population inversion, the excited atoms are required for longer lifetime. A metastable state is such a state. Atoms excited to metastable states remain excited for an appreciable time, which is of the order of 10^{-6} to 10^{-3} seconds. There could be no population inversion and hence no laser action, if metastable does not exist.

15. What are three basic requirements for the systems?

All the laser systems must satisfy the following basic requirements for laser operation:

- Active medium
- Pumping system, and
- Optical resonator.

16. What are the different types of laser available??

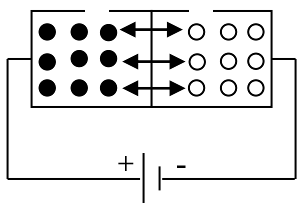
Lasers are classified into five major categories based on the types of active medium. They are:

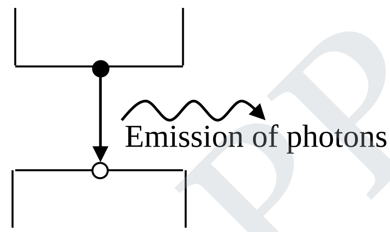
(i) Solid state laser — **Examples**: Ruby laser, Nd-YAG laser
(ii) Gas laser — **Examples**: CO_2 laser
(iii) Semiconductor laser — **Examples**: GaAs laser
(iv) Liquid laser — **Examples**: Europium benzole acetonate dissolved in alchohol, $SeOl_2$ laser
(v) Dye & chemical laser — **Examples**: Rhodamine 6G laser and Coumarin dye laser.

17. What are the applications of Nd-YAG laser?

- It is used in long distance communication system.
- They also find applications in resistor trimming, scribing, micro machining operations as well as welding, drilling etc.
- They find applications in medical field like endoscopy, urology, neurosurgery, ENT, dermatology, dental surgery and general surgery.

18. What is the principle of semiconductor diode laser?





When p-n junction diode is forward biased, electrons from n region and holes from p region recombine with each other at the junction. During recombination process, light is released from certain specified direct band gap semiconductors like Gallium Arsenide. This radiation is called recombination radiation. The corresponding energy is called activation energy.

The wavelength of the light emitted depends on the activation energy. The photons emitted during recombination stimulate other changes and as a result, stimulated emission takes place which leads to laser light.

19. How the light emitting diode different from a semiconductor laser?

S.No	LED	LASER
1.	It requires low current density	It requires high current density
2.	Junction of diode need not be polished	Junction of the diode should be highly polished
3.	Minority carrier injection should take place	Stimulated emission will take place
4.	Power output is low	Power output is high
5.	Intensity is less	Intensity is very high.

20. List the basic components of the oscillator.

All the laser systems must satisfy the following basic requirements for laser operations:

- Active medium
- Pumping system, and
- Optical resonator.

21. What is optical fiber?

Optical fiber is a wave guide, made up of transparent dielectric like glass or plastics in cylindrical form through which light is transmitted by total internal reflection. An optical fiber consists of a central core glass about 50 μm diameter surrounded by cladding about 125 μm to 200 μm diameter which is slightly lower refractive index than core material i.e., $n_1 > n_2$.

22. Define acceptance angle.

Acceptance angle (θ_A) may be defined as the maximum angle that a light ray can have relative to the axis of the fiber and propagate down the fiber.

23. Define fiber optics.

Fiber optics is defined as it is a branch of physics which deals with the transmission and reception of light waves using optical fiber as wave guides.

24. What are the conditions to obtain total internal reflection?

The phenomenon of total internal reflection takes place when it satisfies the following conditions:

(i) Light should travel from denser medium to rarer medium,

i.e., $n_1 > n_2$

where, n_1 is the refractive index of core

n_2 is the refractive index of the cladding material.

(ii) The angle of incidence on core should be greater than the critical angle,

i.e., $\phi > \phi_C$

where, ϕ is the angle of incidence and

ϕ_c is the critical angle.

25. What are the features or advantages of Optical fibers?

- It is light in weight.
- It is smaller in size and is flexible.
- It is non-conductive and non-radiative.
- It has high bandwidth and low loss.
- There is no short circuit in fibers.
- There is no internal noise or cross talk.
- It can withstand even at high temperatures.

26. Define numerical aperture of a fiber.

The sine of the acceptance angle ($\sin\theta_A$) of the fiber is known as numerical aperture (NA). It denotes the light gathering capacity of the optical fiber.

i.e., Numerical aperture (NA) = $\sin\theta_A$.

27. What is meant by fractional index change?

The fractional difference Δ between the refractive indices of the core and cladding is known as fractional refractive index change. It is expressed as, $\Delta = n_1 - n_2 / n_1$.

This parameter is always positive because n_1 must be larger than n_2 for the total reflection condition.

28. Differentiate between single mode and multi mode fiber.

S.No.	Single mode fiber	Multi-mode fibers
1	In single mode fiber only one mode can propagate through the fiber	Multi-mode fiber allows a large number of modes for the light rays traveling through it.
2	It has smaller core dia and the difference between the refractive index of the core and cladding is very small	It has larger core dia and refractive index difference is larger then the single mode fiber.
3	No dispersion i.e., degradation of signals during travel in fiber	There is signal degradation due to multi mode dispersion
4	Fabrication is difficult and costly	Fabrication is less difficult and not costly

29. What is single mode fiber?

In a fiber, if only one mode is transmitted through it, then it is said to be a single mode fiber

30. What is multi mode fiber?

If more than one mode is transmitted through optical fibers, then it is said to be a multi mode fiber.

31. What is attenuation?

Attenuation in fibers means loss of optical power suffered by the optical signal in the fiber itself. It is also known as fiber loss or signal loss.

32. Define total internal reflection.

When light ray travels from denser to rarer medium at an angle of incidence greater than critical angle ($\theta_i > \theta_c$), the incident ray is reflected in the same medium that is in denser medium and this phenomenon is called total internal reflection.

33. What is graded index fiber?

The refractive index of the core decreases when the radial distance increases from axis of the core. It is a maximum at the axis and minimum at the core-cladding interface.

34. List out three different types of losses in fiber optics.

- Absorption
- Rayleigh Scattering and
- Geometric effects

35. Distinguish between step-index and graded index fibers.

Step index fibers	Graded index fibers
The refractive index of the core is uniform throughout and undergoes step change at the cladding boundary.	The refractive index of the core is made to vary in the parabolic manner such that the maximum refractive index is present at the centre of the core
The diameter of the core is about 50 to 200μm in the case of multi mode Step index fiber and 10μm in the case of single	The diameter of the core is about 50 to 200μm in the case of multi mode fiber.

36. Define dispersion.

Dispersion means degradation of the optical signal or signal distortion. In fiber optic communication, the signals is launched in the form of pulses of light with a given width, amplitude and spacing between pulses. During transmission, several effects result in spreading of pulse width. This effect is called dispersion.

37. What are the different types of light sources for optical fiber?

- Light emitting diodes (LED)
- Laser diodes

38. What are types of optical fibers based on number of modes?

(i) Singular mode fiber - only one mode.

(ii) Multi mode fiber - many modes.

39. Classify the fiber optic sensors.

(i) Active sensors, and

(ii) Passive sensors.

40. Explain active and passive sensors with examples.

(i) Active or intrinsic sensor

In the case of intrinsic or active sensor, it senses physical properties such as temperature, pressure etc. and change in transmission characteristic as a result. Different types of active sensors are,

- Intensity modulated sensors
- Phase modulated sensors
- Polarisation modulated sensors and
- Wavelength modulated sensors

Example: Pressure sensor.

(ii) Passive or extrinsic sensors

These types of sensors have separate sensing element and the fiber acts only as a wave guiding media. In this type of sensor, the fiber is used largely as transmission medium.

Example: Displacement sensor.

41. What are the essential components of optical sensors?

- Laser source
- A beam splitter
- Reference fiber, and
- Test fiber

42. What is the basic principle of optical sensors?

A fiber optic sensor in general, consists of a light source. The light source is coupled to an optical fiber. A light detector which receives the signal-carrying light beam as it emerges from the fiber. The signal from detector is processed electrically for getting the desired output.

43. Why is laser much preferred than LED as a optical source?

Laser light is much preferred than LED it is more directional, highly coherent, faster rise time and narrow spectral width than LED.

PART-B

1. Derive an expression for period and amplitude of damped harmonic motion and

2. Discuss the condition for under damped, critical damped and over damped motions.

3. Define Forced vibrations and discuss with necessary theory.

4. Distinguish between free and forced vibrations. State the conditions of resonance. Give some important examples of resonance. What are the important engineering applications of resonance?

5. Atleast how many energy levels are minimum required for the production of laser by a medium? Justify your answer.

6. Derive Einstein's relation for stimulated emission and hence explain the existence of stimulated emission.

7. For atomic transitions, derive Einstein relations and hence deduce the expressions for the ratio of spontaneous emission rate to the stimulated rate to the stimulated emission rate.

8. Discuss the various methods employed to achieve population inversion.

9. Explain the construction and working of a semi-conductor diode laser with diagram.

10. Discuss with theory the construction and working of homo-junction semiconductor laser.

11. Explain with basic principle, the construction and working of one type of optical fibre sensor.

12. Describe the propagation of light through an optical fibre.
(ii)What are numerical aperture and acceptance angle of a fibre? Explain any two applications of optical fibre.

13. Discuss in detail the basic principle and advantages of optical fibres.

14. Classify the optical fibers on the basis of materials, modes of propagation n and refractive index difference.

15. Derive an expression for Numerical aperture and angle of acceptance of a fibre in terms of refractive indices of the core and cladding.

16. What are different types of fibre optical sensors? Explain the working of any two sensors

UNIT III
THERMAL PHYSICS
PART A QUESTIONS

1. Define coefficient of linear expansion.

The coefficient of linear expansion of a solid is the increase in length of unit length of the solid when its temperature is raise by 1K. It is denoted by the letter α.

2. Define superficial expansion.

The coefficient of superficial expansion of a solid is the increase in area produced in unit area of the solid when the temperature is raised by 1°K. It is denoted by the letter β.

3. Define is coefficient of cubical expansion.

Coefficient of cubical expansion of a solid is the increase in volume of unit volume of a solid for 1 K rise of temperature. It is denoted by the letter λ.

4. Define coefficient of apparent expansion of the liquid.

It is the observed increase in volume of unit volume of the liquid per degree Kelvin rise of temperature. It is denoted by $\lambda\alpha$.

5. Define coefficient of real expansion of liquid.

It is the real increase in volume of unit volume of a liquid per degree Kelvin rise of temperature. It is denoted by λr.

6. What is Expansion joint?

An expansion joint or movement joint is an assembly designed to safely absorb the heat induced expansion or contraction of pipeline, duct or vessel. It helps to hold parts together.

7. What is bimetallic strip?

A bimetallic strip means a strip made of two metals pined together. It is like compound bar. It operates on the principle that different metals have different coefficients of expansion.

8. What is thermal insulation?

It will resist the flow of heat to and from a body. It is a material that reduces the rate of heat flow.

9. Define refrigerator.

It is a machine which produced cold. It is used to remove heat from the refrigerated space and reject it to atmosphere. Hence, it maintains the temperature below the surrounding atmosphere.

10. What are heat exchanges?

They are devices used to transfer heat between two or more fluid streams at different

11. Define oven.

An oven is thermally insulated chamber used for heating, baking or drying of a substance and most commonly used for cooking

Kilns and furnaces are special-purpose ovens, used in pottery and metalworking, respectively.

12. What is solar power?

The energy (heat and light) obtained from the sun, is called solar energy. Sun is the source of all energy. Sunlight contains infrared radiations in large proportion, and these infrared rays heats all objects on which they fall.

13. What are the basic entities responsible for thermal conduction of a solid?

i) Area of cross section (A)
ii) Temperature difference between the hot and cold layers of the solid ($\theta_1 - \theta_2$)
iii) Time of Conduction (t)
iv) Thickness of the solid (x)

14. 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 cross section, maintained at unit temperature gradient.

(i.e.) $\mathbf{K = Qx / A(\theta_1 - \theta_2)\ W\ m^{-1}K^{-1}}$

15. How are heat conduction and electrical conduction analogous to each other?

Sl No	Heat Conduction	Electrical Conduction
1	Heat is conducted from a point of higher temperature to a point of lower temperature.	Electricity is conducted from a point at higher potential to a point at lower potential.
2	In metal Heat conduction is mainly due to free electrons and the contribution due to lattice variations is negligible.	In metals electrical conduction is due to free charge carriers namely electrons. In semi-conductors both electrons and holes contribute for the electrical conduction.
3	In non metals heat conduction is only due to lattice vibrations.	In insulators, at high voltages, electric breakdown occurs.
4	The ability to heat conduct is measured by thermal conductivity which defined as the quantity of heat conducted per second through unit area of the material when unit temperature gradient is maintained. Unit for thermal conductivity is $W\ m^{-1}K^{-1}$	The ability to conduct electricity is measured by electrical conductivity which is defined in the total electrical charge flowing per second per unit area of the conduction when unit potential gradient is maintained. Unit for Electrical conductivity is $mhom^{-1}$
5	Thermal resistance of the conductor $= \frac{\text{Temperature gradient}}{\text{Thermal current flow}} = \frac{\Delta T}{Q}$	Electrical resistance of the conductor $= \frac{\text{Potential gradient}}{\text{Electrical current flow}} = \frac{\Delta V}{i}$

16. Distinguish between conduction and convection?

Conduction: It is the process in which the heat is transferred from hot end to cold end without the actual movement of the particles.

Convection: It is the process in which the heat is transmitted from hot end to cold end without the actual movement of the particles.

17. Define Radiation and give example.

It is the process in which the heat is transmitted from one place to another without the necessity of the intervening medium.

Example: The rays from the Son reacting the Earth.

18. What is meant by Temperature gradient?

The rate of fall of temperature with respect to the distance is called as **temperature gradient.** In general it is denoted as $-d\theta/dx$. The negative sign indicates the fall of the temperature with increases in distance.

19. Define thermal diffusivity.

It is defined as the ratio of thermal conductivity to the thermal capacity per unit volume of the material

$$\text{Thermal diffusivity (h)} = \frac{\text{Thermal conductivity}}{\text{Thermal Capacity}}$$

Since thermal capacity is the product of specific heat capacity(s) and density of the material (ρ), we can write

$$h = k/\rho s \ m^2 s^{-1}$$

20. Define Newton's Law of Cooling?

Newton's Law: The rate of loss of heat of the body is directly proportional to the temperature difference between the body and its surrounding, of same nature.

21. Derive the unit for Thermal Conductivity?

The Thermal Conductivity of the material is $K = \frac{Qx}{A(\theta_1-\theta_2)\,t}$

$$= \frac{\text{Joules} \times \text{metre}}{(\text{metre})^2 \times \text{kelvin} \times \text{second}} = \frac{\text{watts}}{\text{metre} \times \text{kelvin}}$$

The unit of thermal Conductivity is $Wm^{-1}K^{-1}$.

22. Give the methods of determining the thermal conductivity of good and bad conductors.

The methods of determining the thermal conductivity of good and bad conductors are:

- Searle's Method– Good conductors like metallic rod
- Forbe's method– for determining absolute conductivity of metals
- Lee's disc method– for bad conductors
- Radial flow method - for bad conductors

23. What is the basic principle employed in lee's disc Method for bad conductor?

The given bad conductor is taken in the form of disc and is placed in between the disc and the chamber. The steam is passed through bad conductor. The steam is passed through bad conductor. Heat conducted through the bad conductor per second is calculated. Amount of heat lost per second by the disc is also calculated. When steady state is reached,

The amount of heat conducted through bad conductor per second = Amount of heat lost per sec by the disc.

24. Why the specimen used to determine thermal conductivity of a bad conductor should have larger area and smaller thickness?

For bad conductor with a smaller thickness and larger area of cross section, the amount of heat conducted will be more.

25. What is meant by thermal resistance?

The thermal resistance of a body is measure of its opposition to the flow of heat through it. (i.e.) every body posses some resistive power when it is subjected to heat. This resistive power is termed as thermal resistance.

PART – B

1. Discuss Prevost theory of heat exchanges?

2. Explain some practical uses of thermal expansion of substances?

3. Describe the Forbes method to determine the thermal conductivity of good conductors?

4. Derive the equation for heat conduction along a bar and solve it for steady state condition.

5. Derive an equation for one-dimensional flow of heat and solve it under steady state condition.

6. Derive an expression for the quantity of heat flow through a metal slab whose faces are kept at two different temperatures. Use this expression to determine the thermal conductivity of a bad conductor by Lee's disc method.

7. Describe Lee's disc method to find the co-efficient of thermal conductivity of a bad conductor.

8. Derive an expression for the flow of heat through a compound media.

9. Explain the working of heat exchangers.

ator. Describe principle and working of a refrigerator.

UNIT IV
QUANTUM PHYSICS
PART A QUESTIONS

1. Explain Planck's hypothesis or what are the postulates of Planck's quantum theory?

- The black body radiation chamber is filled up not only with radiations but also with a large number of oscillating particles. The particles can vibrate in all possible frequencies.
- The frequency of radiation emitted by an oscillator is the same as that of the frequency of that vibrating particle.
- The oscillatory particles cannot emit energy continuously. They will radiate energy only in the form of a discrete packet of energy, i.e., a small unit called quantum or photon, and
- The vibrating particles can radiate energy when the oscillators move from one state to another. The radiation of energy is not continuous, but discrete in nature. The values of energy of the oscillators are like 0, hγ, 2hγ, 3hγ…nhγ.

2. What is meant by blackbody radiation??

A perfect black body is one that absorbs radiation of all wavelengths incident on it. Further, such a body cannot transmit or reflect any radiation and therefore it appears black. A black body can radiate energy in all possible wavelengths when it is heated to a suitable temperature. The radiation emitted from black body is known as black body radiation or total radiation.

3. What is the physical significance of a wave function?

(i) It relates the particles and wave nature of matter elastically.

(ii) It is a complex quantity and hence we cannot measure it.

(iii) The square of the wave function is a measure of the probability of finding the particle at a particular position. It cannot predict the exact location of the particle.

(iv) The wave function is a complex quantity, where as the probability is a real and positive quantity. Therefore, position probability density P(r,t) is defined as the product of the wave function and its conjugate as,

$$\text{i.e., } P(r,t) = \psi(r,t)\,\psi^*(r,t) = |\psi(r,t)|^2$$

(v) The probability of finding the particle within a volume of dτ is

$$P = \int |\psi|^2 \, d\tau, \text{ where } d\tau = dxdydz$$

(vi) If the particle is definitely present, then its probability value is one,

$$\text{i.e., } P = \int_{-\infty}^{+\infty} |\psi|^2 \, d\tau = 1$$

The wave function has no physical meaning, where as the probability density has a definite physical meaning.

4. What is wave function?

A variable quantity that characterizes de Broglie waves is known as wave function and is denoted by the symbol ψ. The value of the wave function associated with a moving particle at point (x, y, z) and time 't' gives the probability of finding the particle at that time and at that point.

5. What is Schrodinger wave equation?

Schrodinger wave equation is a mathematical equation to describe the dual nature of matter waves. Schrodinger equation is one of the basic quantum mechanical equations. This equation is used to describe both macroscopic as well as microscopic particles.

6. Write down the Schrodinger time independent and dependent wave equations.

Schrodinger time independent equation,

$$\left[\nabla^2 \psi + \frac{2m(E - V)\,\psi}{\hbar^2}\right] = 0$$

Schrodinger time dependent equation,

$$H\psi = E\psi$$

Where, ∇ is the Laplacian operator

E is the energy operator, and

H is the Hamiltonian operator.

7. Mention some important applications of quantum mechanics.

1. Quantum mechanics is used to explain the concept of photoelectric effect.
2. Based on quantum ideas, the problem of specific heat of solids at low temperature is explained successfully.
3. The atomic structure and the origin of spectral lines are explained by Bohr based on quantum concepts.
4. The phenomenon like Scattering of X-rays are explained by Compton based on quantum ideas.

8. What are the different types of scattering of X-rays?

(i) Coherent scattering or Classical scattering.

(ii) Incoherent scattering or Compton scattering.

9. What is zero point energy?

The possible energies of a particle in a base of length L is given by,

$$E = n^2h^2 / 8mL^2$$

If n=1, then $E = h^2 / 8mL^2$

This is the energy of the ground state of the particle. Since, the particle in a box cannot be at rest, its minimum energy is positive and is often called the zero point energy.

10. State Wien's displacement law.

According to Wien's displacement law, in the energy spectrum of a black body the product of the wavelength corresponding to maximum energy (λ_m) and absolute temperature is a constant.

i.e., $\lambda_m T$ = constant.

11. State Rayleigh – Jean's law.

According to Rayleigh – Jean's law, the energy distribution in the black body spectrum is given by,

$E_\lambda = 8\pi kT / \lambda^4$

Where, k is Boltzman constant.

12. State Planck's quantum theory of radiation.

According to Planck's theory, energy is emitted in the form of pockets or quanta called photons and energy of photons is given by E = nhγ where n=1,2,3, etc. In black body radiation, total energy of photons within the wavelength range λ and λ+dλ is given by,

$E_\lambda = 8\pi hc/ \lambda^5 [\exp(h\gamma / kT) - 1].$

13. What is scanning tunneling microscope?

In 1981, Gerd Binning and Heinrich Rohrer developed the scanning tunneling microscope (STM), a significantly superior tool for observing surfaces atom by atom.

STM is the highest resolution imaging and nano fabrication technique available. It relies on quantum tunneling of electrons from a sharp metal tip to a conducting surface.

14. What is the principle of scanning tunneling microscope?

STM has metal needle that scans a sample by moving back and forth over it, gathering information about the curvature of the surface and follow the smallest changes in the contours of a sample. The needle doesn't touch the sample, however, but stays about the width of two atoms above it.

15. What are the applications of STM?

- The STM shows the positions of atoms or more precisely, the positions of some of the electrons.
- Uses of STM to study metals and semiconductors surface can provide non-trivial real space information especially in studying semiconductor such as Si (100) surface.
- One innovative of STM recently found is manipulation of atoms. For example, Iron atoms are placed on Cu surface and dragged by the STM tip and moves across the surface to a desired position. Then, the tip was withdrawn by lowering the tunneling current.
- To analyze the electronic structures of the active sites at catalyst surfaces.

16. What are the disadvantages of STM?

- A small vibration, even a sound, could smash the tip and the sample together.
- A single dust particle, for example, could damage the needle.

PART B QUESTIONS

1. Arrive at the Schrodinger wave equation and apply the same for a particle in a rectangular box to obtain the energy Eigen values and the corresponding Eigen functions

2. (i) What is meant by black body radiation.
   (ii) Using quantum theory, derive an expression for the average energy emitted by the black body and arrive at Planck's radiation law.

3. With the concepts of quantum theory of black body radiation derive an expression for energy distribution and use it to prove Wien's displacement law and Rayleigh- Jeans law.

4. Derive an expression for Planck's radiation law and discuss the same for shorter and longer wavelengths.

5. (i) What are the draw backs of classical free electron theory.
   (ii) Explain the de-Brogile concept of wave nature.
   (iii) Derive Schrodinger time dependent and time independent wave equations.

6. With the quantum concepts explain the energy level of an electron enclosed in an infinity deep one dimensional potential box.

7. Derive the Schroedinger time independent wave equation for a free particle enclosed in a one dimensional potential well of length 'a' with infinite potential barriers and get the normalized wave function for the free particle.

8. Based on quantum physics show that the energy levels of an electron are discrete.

9. Arrive at the Eigen values and Eigen functions for an electron enclosed in a one dimensional potential box and extend the same for a three dimensional box.

10. Explain the phenomenon of quantum tunneling across a thin barrier of width L using the Schrodinger wave equation.

11. Explain in detail the construction and working of scanning tunneling microscope with necessary diagram.

UNIT V
CRYSTAL PHYSICS
PART A QUESTIONS

1. **Define unit cell.**

The unit cell is defined as the smallest geometric figure, the reception of which gives the actual crystal structure. The unit cell is also defined as fundamental elementary pattern of minimum of atoms, molecules or groups of molecules which represent fully all the characteristic of the crystal.

2. **What are Miller indices?**

Miller indices are a system with a set of three numbers within parenthesis to designate a plane in a crystal. This set of three numbers is known as Miller indices of the plane. Crystal direction is represented as a set of three numbers within the square bracket.

Miller indices are the three possible integers which have the same ratios as the reciprocals of the intercepts of the plane concerned on the three axes.

3. **Define space (or) crystal lattice**.

The three dimensional space lattice is defined as an infinite array of imaginary points in space such that every point has surroundings identical to that of every other point in the array. Each point in the space lattice is called lattice points.

4. **Bismuth has a=b=c=4.7 Ǻ and angles α=β=γ=60˚. What is its crystal structure?**

Since a=b=c and α=β=γ, crystal structure of Bismuth is Trigonal or Rhombohedral.

5. **What is primitive cell?**

A primitive cell is the smallest unit cell all in volume constructed by primitive only one full atom.

6. **What are Bravais lattices?**

According to Bravais, there are fourteen possible independent ways of arranging points in three dimensional space. These fourteen possible space lattices of the seven crystal systems are called Bravais lattices.

7. **Define packing factor (or) packing density (or) density of packing and give its unit.**

The packing density is the ratio between the total volume occupied by the atoms or molecules in an unit and the volume of the unit cell.

$$\text{i.e., packing density} = \frac{\text{Total volume occupied by atoms in a unit cell}}{\text{Volume of the unit cell}}$$

$$= \frac{\text{Number of atoms present in unit cell * volume of atom}}{\text{Volume of the unit cell}}$$

Since, atomic packing factor is the ratio; it does not have any unit.

8. **What are the lattice parameters of a unit cell?**

The characteristic intercepts on the axes a, b, and c and the interfacial angles, α, β and γ

9. Name the seven crystal systems.

The seven crystal systems are as follows:

(i) Cubic

(ii) Tetragonal

(iii) Orthorhombic

(iv) Monoclinic

(v) Triclinic

(vi) Trigonal, and

10. Define coordination number.

The coordination number of an atom in a crystal is the number of nearest atoms directly surrounding with that atom. If the coordination number is high, then the structure will be more closely packed. It signifies the tightness of packing of atoms in the crystal.

11. Define atomic radius.

Atomic radius is defined as half of the distance between any two nearest neighbor atoms that have direct contact with each other, in a crystal of a pure element. It is usually expressed in terms of cube edge a (lattice parameter).

12. Calculate the packing factor of simple cubic (sc) crystal structure.

$$\text{Packing factor} = \frac{\text{Number of atoms present in unit cell x Volume of atom}}{\text{Volume of the unit cell}}$$

$$= \frac{1x\ (4/3)\ \pi r3}{a^3}$$

We know, r = a /2, therefore,

$$\text{Packing factor} = \frac{(4/3)\ \pi a3}{a^3}$$

$$= \pi/6$$

$$PF = 0.52$$

13. Calculate the packing factor of body centered cubic (bcc) crystal structure.

The number of atoms present in a unit cell =2 atoms

$$\text{Packing factor} = \frac{\text{Number of atoms present in unit cell x Volume of the unit cell}}{\text{Volume of the unit cell}}$$

$$= \frac{2x\ (4/3)\ \pi r3}{a^3}$$

We know, $r = \frac{\sqrt{3}}{4} a$, therefore,

$$\text{Packing factor} = \frac{2x\ (4/3)\ \pi\ (\sqrt{3}/4\ a)^3}{a^3}$$

$$= \frac{\sqrt{3}\ \pi}{8}$$

14. Calculating the packing factor of face centered cubic (fcc) crystal structure.

The number of atoms present in an fcc unit cell is four. Therefore, the packing factor of the fcc unit cell can be written as,

$$\text{Packing factor} = \frac{4[(4/3)\pi r^3]}{a^3}$$

We know, atomic radius $r = a / 2\sqrt{2}$

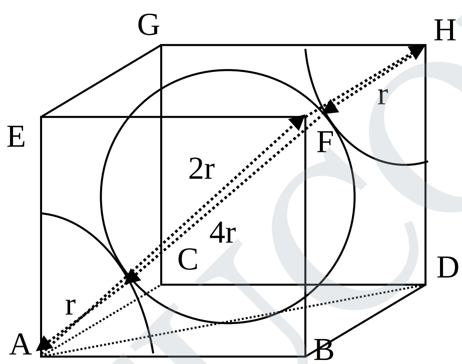
$$\text{Therefore, Packing factor} = \frac{4x\,(4/3)\,\pi\,(a / 2\sqrt{2})^3}{a^3}$$

$$PF = \pi / 3\sqrt{2} = 0.74$$

15. Calculate the atomic radius for body centered cubic (BCC) structure.

For a body centered unit cell, the atomic radius can be calculated from the above figure as follows: AH = 4r and DH = a

From the triangle AHD,



$$AH^2 = AD^2 + DH^2$$

From the triangle ABD,

$$AD^2 = AB^2 + BD^2$$

$$AD^2 = a^2 + a^2$$

$$AD = \sqrt{2}\,a$$

Substitute equation (2) in equation (1),

$$AH^2 = 2a^2 + a^2$$

$$(4r)^2 = 3a^2$$

$$r^2 = \frac{3a^2}{16}$$

$$\text{The atomic radius } r = \frac{\sqrt{3}}{4}a$$

16. What is the relation between lattice constant 'a' and density 'ρ' of the crystal?

$$\text{Density } \rho = \frac{\text{(Number of atoms per unit cell) x (atomic weight)}}{\text{(Avogadro's number) x (lattice constant)}^3}$$

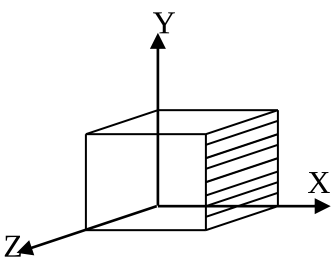
$$\rho = \frac{nA}{Na^3}$$

17. State the expression for interplanar spacing for a cubic system interms of lattice constant and Miller indices.

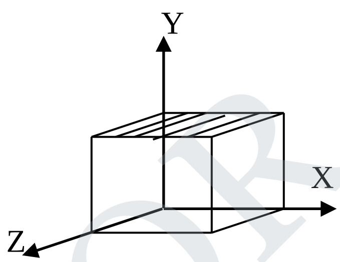
The interplanar distance (d) = $a / \sqrt{h^2+k^2+l^2}$

Where, a is lattice constant
h, k, l are Miller indices.

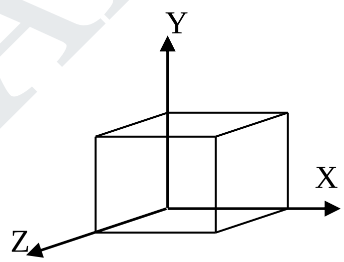
18. Sketch (10 0), (0 1 0) and (1 1 1) planes for a cubic crystal.



(a) (1 0 0)plane



(b) (0 1 0)plane



(c) (1 1 1)plane

19. What is a crystal structure?

A basis is an assembly of atoms identical in composition, arrangement and orientation. When the basis is repeated with correct periodicity in all directions, it gives actual crystal structure.

Thus, Space lattice + Basis ⇒ Crystal structure.

20. Name the crystalline structure of the following:
(a) Gold, (b) Germanium, (c) Barium and (d) Zinc

(a) Gold - fcc
(b) Germanium - Diamond
(c) Barium - bcc

21. What are crystalline materials?

The materials, which have a regular and periodical arrangement of atoms in a solid, are known as crystalline materials.

22. Classify the crystalline materials.

A crystalline material is classified into two categories.

- Single crystals

23. What is non-crystalline or amorphous solid? Give examples.

The materials in which the atoms in solid are arranged in an irregular pattern are known as non-crystalline or amorphous materials.

Examples: Plastic and rubber.

24. Differentiate crystalline and non-crystalline materials.

S.No	Crystalline Materials	Non-Crystalline Materials
1.	They are isotropic	They are anisotropic.
2.	They have a definite and regular geometrical shape.	They don't have definite geometrical shape.
3.	They are most stable.	They are less stable.
4.	Examples: NaCl and KCl	Plastic and glass.

25. Define inter atomic and Interplanar distance.

The distance between any two atoms is called inter atomic distance. The distance between any two planes is called interplanar distance.

26. Give the number of atoms, coordination number and packing density of unit diamond cell.

Number of atom per unit cell = 8 atoms
Coordination of number = 4
Packing density =34%

27. Graphite acts as good conductor but diamond does not conduct an electric current. Why?

In diamond all four outer electrons of each carbon atom are 'localised' between the atoms in covalent bonding. The movement of electrons is restricted and diamond does not conduct an electric current. In graphite, each carbon atom uses only 3 of its 4 outer energy level electrons in covalently bonding to three other carbon atoms in a plane. Each carbon atom contributes one electron to a delocalised system of electrons that is also a part of the chemical bonding. The delocalised electrons are free to move throughout the plane. For this reason, graphite conducts electricity along the planets of carbon atoms, but does not conduct in a direction at right angles to the plane.

28. What are the techniques adopted for growing crystals?

The various crystal growth techniques are

(a) Solution growth
(b) Melt growth and (c) Vapour growth

29. What is meant by Solution Growth?

The material to be grown is dissolved using a solvent and is kept ideal until the super saturation state is achieved. At some degree of super saturation, parent nuclei is formed, which leads to further growth of crystal.

The solvents commonly used are water, organic liquids (or) molten salts.

30. List out the various types of melt growth?

The various melt growth technologies are

(a) Normal freezing
(b) Crystal Pulling
(c) Zone melting
(d) Flame fusion

31. What is the principle used in the Bridgman Technique for growing crystals?

In this technique the material is heated to a very high temperature until the molten stage is reached. The molt is moved across the temperature gradient so as to solidify and form a seed. Further such movements will lead to the crystal growth.

32. What is the principle used Czochralski method?

"Crystal pulling from the melt" is the principle used Czochralski method. Here the material is melted over the monocrystalline seed is rotated. Further, with the help of pull rod it is slowly drawn upwards and hence the melt freezes on the crystal and thus the crystal grows.

33. State the conditions imposed on the cell parameters for crystal systems having the largest of bravais lattices and the least number of nearest neighbors.

(i) System having the largest number of Bravais lattices is orthorhombic. Its cell parameters are: $a \neq b \neq c$; $\alpha = \beta = \gamma = 90^o$

(ii)System having the least number of nearest neighbors is diamond cubic (4). Its cell parameters are: $a = b = c$; $\alpha = \beta = \gamma = 90^o$.

34. Write the different types of crystal defects.

(i) Point defects (zero dimensional)

(a) Impurity defect

(i) Substitutional impurity defect
(ii) Interstitial impurity defect

(b) Vacancies

(i) Frenkel defect
(ii) Schottky defect

(ii) Line defects (one dimensional)

(a) Edge dislocation
(b) Screw dislocation

(iii) Surface defects (two dimensional)

(a) Grain boundaries
(b) Twin boundaries
(c) Tilt boundaries
(d) Stacking faults
(e) Ferromagnetic domain walls

(iv)Volume defects (three dimensional)

(a) Cavities or voids

35. Define line defect.

The defect along a line is called line defect. There are two types of line defects

(i) Edge dislocation and

(ii) Screw dislocation.

36. Distinguish edge and screw dislocations.

An edge dislocation arises when one of the atomic planes forms only partially and does not extend through the entire crystal.

Screw dislocation is due to a displacement of atoms in one part of a crystal relative to rest of the crystal.

37. What are Burgers vector.

The magnitude and the direction of the displacement due to edge dislocation are defined by a vector called Burger's Vector.

38. What is crystal defect?

The deviation from the regularity of arrangement of atoms is called crystal imperfection or crystal defect.

39. What is impurity defect? What are types of impurity defects?

A foreign substance added to a crystal is called impurity. The impurity atom may fit in the structure in two ways giving rise to two kinds of impurity defects.

(i) Substitution impurity defect

(ii) Interstitial impurity defect.

40. What are vacancies?

Vacancies are empty atomic sites. Vacancies may occur as a result of imperfect packing during the original crystallization or they may arise from the thermal vibrations of atoms at higher temperatures.

There are different kinds of vacancies like Frenkel defect, Schottky defect, Colour centers etc.

41. What is Frenkel defect?

A vacancy associated with interstitial impurity is called Frenkel defect.

42. What is Schottky defect?

If an atom is missing from its lattice site, the vacancy is called Schottky defect.

43. What are twin boundaries?

If the atomic arrangement on one side of the boundary is the mirror image of the arrangement on the other side the defect is called twin boundaries.

44. What is stacking fault?

This defect arises due to defect in the stacking of atomic planes. In some cases a part of certain atomic plane will be missing where as in some other cases a portion of extra atomic plane is present, changing the sequence of arrangement of atoms.

PART B QUESTIONS

1. Show that the packing factor for FCC and HCP are equal.

2. (i)Define packing factor of a unit cell
(ii) Obtain the expression for packing factor of face centered cubic and body centered cubic unit cells.

3. Derive an expression for the packing factor of copper. What do you infer from that?

4. (i) Explain the term atomic radius, co-ordination number and packing factor.
(ii) Determine the atomic radius, co-ordination number and packing factor for BCC and FCC structures.

5. Explain the various types of crystal systems with a neat sketch and example.

6. (i) Explain the following terms: (a) Space lattice (b) basis (c) unit cell
(ii) Define the terms atomic radius and packing factor. Calculate the above for SC, BCC and FCC structures.

7. Explain the characteristics of a unit cell of the simple cubic system.

8. Explain the characteristics of a unit cell of the body centered cubic system.

9. Explain the characteristics of a unit cell of the face centered cubic system.

10. Describe the structure of HCP crystal. Obtain the relation between c and a and hence calculate the atomic packing factor.

11. Define atomic packing factor. Calculate the packing factor for
(a) SC (b) BCC (c) FCC (d) HCP unit cells

12. What are Miller indices? Explain how they are determined with any two planes in SC structure. Give their significance.

13. What are Miller indices? Sketch two successive (110) planes. Show that for a cubic lattice the distance between two successive plane (hkl) is given by

$$d = \frac{a}{\sqrt{h^2+k^2+l^2}}$$

14. Explain the Bridgman and Czochralski techniques for growing crystals.

15. Describe the various crystal growth techniques.

16. Briefly explain the chemical vapour deposition (CVD) method.

17. Explain the physical basis of classifying crystals into 7 systems and 14 bravais lattices.

18. Explain in detail the different types of line and surface defects.

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