BT505 - BIOSENSORS

MID TERM IMPORTANT QUESTIONS

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Admin: **BS Biological Sciences** (One place to all your solutions)

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1. How laser beam is created?

A laser beam is created when a material (gain medium) is supplied with energy, usually by electricity in biosensors. This energy excites atoms, and when they return to normal, they release light (photons). These photons trigger other excited atoms to release more identical photons. This process is called stimulated emission. The light is reflected between mirrors inside the device, making it stronger and more organized. Finally, a narrow, strong, and single-color laser beam comes out, which is used in biosensors for accurate detection.

2. Explain Kidney based biosensors.

Kidney-based biosensors are devices used to monitor kidney function by detecting specific biological markers in blood, urine, or other body fluids. They work by using a biological sensing element (such as enzymes, antibodies, or cells) that reacts with kidney-related substances like urea, creatinine, uric acid, or electrolytes**.** When these substances interact with the sensor, a signal (electrical, optical, or chemical) is produced. This signal is then converted into measurable data. These biosensors are important for:

- Early detection of kidney diseases
- Monitoring patients with chronic kidney failure
- Managing dialysis treatment
- Checking waste levels in blood

3. Write a note olfactory cell biosensor.

An olfactory cell biosensor is a type of biosensor that uses olfactory (smell) cells or olfactory receptors as the biological sensing element to detect odors or volatile chemical compounds. These olfactory cells naturally respond to specific smell molecules. When an odor molecule binds to the receptor on the olfactory cell, it produces a biological signal, usually in the form of electrical activity. This signal is detected by a transducer, which converts it into an electrical output that can be measured and analyzed. Olfactory cell biosensors are highly sensitive and can detect very low concentrations of chemicals, making them useful for:

- Food quality testing (detecting spoilage or contamination)
- Environmental monitoring (detecting toxic gases or pollutants)
- Medical diagnosis (identifying disease-related odor markers)
- Security applications (detecting explosives or hazardous substances)

4. Name three electrodes used in biosensors.

Three electrodes used in biosensors are:

- ***Working electrode*** – where the biochemical reaction occurs and the main signal is generated.
- ***Reference electrode*** – provides a stable and constant voltage for comparison.
- ***Counter (auxiliary) electrode*** – completes the electrical circuit by allowing current flow.

5. What are two physical parameters used for machine designing?

Two physical parameters used in machine (biosensor device) design are:

- ***Temperature*** – affects enzyme activity, reaction rate, and sensor stability.
- ***Pressure*** – influences fluid flow and measurement accuracy in sensor systems.

6. Write some examples of bioreceptors.

Examples of bioreceptors used in biosensors are:

- Enzymes (e.g., glucose oxidase, urease)
- Antibodies (used for antigen detection)
- Nucleic acids (DNA/RNA probes)
- Cells (such as microbial or olfactory cells)
- Receptor proteins (hormone or neurotransmitter receptors)

7. What is Piezoelectric biosensor?

A piezoelectric biosensor is a type of biosensor that detects biological interactions by measuring changes in mass or pressure on a piezoelectric crystal. It uses a material (like quartz) that produces an electrical signal when mechanical stress is applied. When biomolecules (such as proteins or DNA) bind to the surface of the crystal, the added mass changes its vibration frequency. This change is converted into an electrical signal. It is used for:

- Detecting pathogens
- Measuring biomolecular binding
- Medical diagnostics
- Environmental monitoring

8. What are the dependencies in enzyme biosensor?

The performance of an enzyme biosensor depends on several factors:

- ***Temperature*** – affects enzyme activity and stability
- ***pH*** – enzymes work best at an optimum pH level
- ***Substrate concentration*** – determines the strength of the signal produced
- ***Enzyme activity/stability*** – active enzymes give better and longer-lasting responses
- ***Immobilization method*** – how the enzyme is fixed on the sensor surface affects efficiency
- ***Presence of inhibitors or contaminants*** – can reduce enzyme performance

9. How are the electrochemical categorized in the biosensors?

Electrochemical biosensors are categorized into:

- ***Amperometric biosensors*** – measure current produced by oxidation-reduction reactions
- ***Potentiometric biosensors*** – measure change in voltage (potential) without current flow
- ***Conductometric biosensors*** – measure changes in electrical conductivity of the solution
- ***Impedimetric biosensors*** – measure changes in electrical impedance

10. Write the types of electrochemical biosensors.

Amperometric biosensors – measure the electric current produced during a redox (oxidation-reduction) reaction. The current is proportional to the concentration of the target substance (e.g., glucose biosensor).

Potentiometric biosensors – measure the change in electrical potential (voltage) between electrodes when ion concentration changes, without drawing significant current (e.g., pH and ion-selective sensors).

Conductometric biosensors – measure changes in electrical conductivity of the solution caused by biochemical reactions that produce or consume ions.

Impedimetric biosensors – measure changes in electrical impedance (resistance to AC current) when biomolecules bind to the sensor surface, often used for label-free detection.

11. What is physiological sensor and how it works?

A physiological sensor is a biosensor that measures biological or bodily parameters such as heart rate, body temperature, blood pressure, oxygen level, or glucose level. It works by detecting a physical or biochemical change in the body and converting it into an electrical signal. First, the sensor detects a physiological change (for example, heartbeat or oxygen concentration). Then a transducer converts this change into an electrical signal. This signal is processed and displayed as readable data. Common examples include:

- Heart rate monitors (ECG sensors)
- Blood oxygen sensors (pulse oximeters)
- Temperature sensors
- Glucose monitoring sensors

12. What is pulse oximeter?

A pulse oximeter is a physiological biosensor that measures the oxygen saturation level (SpO_2) in blood and the pulse rate**.** It works by passing two wavelengths of light (red and infrared) through a thin part of the body, usually a fingertip or earlobe. Oxygenated and deoxygenated hemoglobin absorb light differently. A detector measures how much light passes through, and the device calculates:

- Oxygen saturation level in blood
- Heart/pulse rate

13. How buzzing sound is produced in mosquitoes?

Mosquitoes produce a buzzing sound due to the rapid movement of their wings during flight. When mosquitoes fly, their wings beat at a very high frequency (hundreds of times per second). This fast vibration disturbs the surrounding air and creates pressure waves, which we hear as a buzzing sound. In biosensor perspective, this type of vibration-based sound production can be compared to mechanical signal generation, where movement or oscillation produces detectable physical signals.

14. What are the effects of Surface Plasmon Resonance (SPR)?

- It produces a change in reflected light intensity when biomolecules bind to a metal surface (usually gold).
- It causes a shift in resonance angle or wavelength depending on mass changes at the sensor surface.
- It increases sensitivity for detecting biomolecular interactions without using labels.
- It allows real-time monitoring of binding events (like antigen–antibody interactions).
- It enables detection of very small changes in refractive index near the sensor surface.

15. What is ELISA and how it is performed?

ELISA (Enzyme-Linked Immunosorbent Assay) is a biochemical biosensor technique used to detect and measure specific proteins, antigens, or antibodies in a sample. It works on the principle of antigen–antibody binding combined with an enzyme reaction that produces a color change.

How ELISA is performed:

- A specific antigen or antibody is attached to the surface of a microplate well.
- The sample is added, and if the target molecule is present, it binds to the coated surface.
- A second antibody linked with an enzyme is added, which binds to the target complex.
- A substrate is added, and the enzyme converts it into a colored product.
- The intensity of the color is measured using a reader, which indicates the concentration of the target substance.

16. What are the advantages of miniaturization?

- Requires very small sample volume, making it suitable for limited or precious biological samples
- Faster response time because molecules travel shorter distances in micro-scale systems
- High sensitivity and accuracy due to better control over reaction conditions
- Low cost because less reagents and materials are needed
- Portable and compact devices, suitable for field and bedside testing
- Enables real-time monitoring of biological processes
- Reduces power consumption in electronic biosensor devices
- Allows integration with microfluidic and lab-on-a-chip systems for advanced diagnostics

17. What is pressure sensor and its mechanism?

A pressure sensor is a device that measures force applied per unit area (pressure) and converts it into an electrical signal for analysis.

Mechanism:

When pressure is applied, it causes a physical deformation in a sensing element, usually a thin diaphragm or flexible membrane. This mechanical deformation is then converted into an electrical output using different transduction principles:

- ***Piezoresistive mechanism*** – the applied pressure changes the resistance of a material (such as silicon). This change in resistance is measured as an electrical signal.
- ***Capacitive mechanism*** – pressure reduces or increases the distance between two capacitor plates, changing capacitance, which is then converted into voltage or digital output.
- ***Piezoelectric mechanism*** – certain materials (like quartz or PZT) generate an electric charge when mechanical stress is applied.

18. Enlist label free biosensors.

- Surface Plasmon Resonance (SPR) biosensors
- Quartz Crystal Microbalance (QCM) biosensors
- Interferometric biosensors
- Field-Effect Transistor (FET) biosensors
- Impedimetric biosensors
- Optical waveguide biosensors
- Cantilever-based biosensors

19. What is the difference between intrinsic and extrinsic biosensors?

Intrinsic biosensors

- The biological recognition element is an integral part of the sensing material itself
- Signal is generated within the biological system or material
- No external labeling is required
- Example: genetically modified cells that produce a signal when exposed to a target

Extrinsic biosensors

- The biological recognition element is separate and attached to the sensor surface
- Signal is produced due to interaction between analyte and external bioreceptor
- Usually requires immobilization of enzymes, antibodies, or DNA on a transducer
- Example: glucose biosensor using immobilized glucose oxidase

20. How immuno sensor is designed?

An immunosensor is designed by combining an immunological reaction (antigen–antibody binding) with a physicochemical transducer.

Design process:

- A bioreceptor layer (antibody or antigen) is selected that can specifically bind to the target molecule.
- This bioreceptor is immobilized on the surface of a transducer (such as optical, electrochemical, or piezoelectric surface).
- A sample containing the target antigen/antibody is introduced.
- Specific binding occurs between antigen and antibody, forming a complex.
- This interaction produces a detectable signal (electrical, optical, or mass change), which is measured by the transducer and converted into output data.

21. What is Quartz crystallite?

A quartz crystallite is a small, highly ordered crystal of quartz (silicon dioxide, SiO_2) that has piezoelectric properties. In biosensors, it is commonly used in Quartz Crystal Microbalance (QCM) devices because it can vibrate at a very stable frequency when an electric field is applied. When mass is added to its surface (such as biomolecules binding), its vibration frequency changes, which is used for sensitive detection.

22. Write importance of HRP enzyme.

HRP (Horseradish Peroxidase) is an important enzyme used widely in biosensors, especially in ELISA and immunosensors**.**

Importance of HRP enzyme:

- Acts as a label enzyme in immunoassays to produce detectable signals
- Catalyzes reactions that generate a color change, light, or electrochemical signal
- Provides high sensitivity for detecting very low concentrations of biomolecules
- Works efficiently with many substrates (e.g., TMB, DAB)
- Stable and easy to conjugate with antibodies or antigens
- Widely used in ELISA tests for disease detection and diagnostic biosensors

23. Write physical quantities of support material.

Physical quantities of support material (used in biosensors for immobilization or electrode support) include:

- ***Surface area*** – larger surface area provides more space for bioreceptor attachment
- ***Porosity*** – affects diffusion of analytes and reaction efficiency
- ***Mechanical strength*** – ensures stability and durability of the sensor structure
- ***Electrical conductivinb ty*** – important for electrochemical signal transfer
- ***Thermal stability*** – ability to maintain structure under temperature changes
- ***Surface roughness*** – improves binding of biomolecules and sensitivity

24. What is MEMS?

MEMS (Micro-Electro-Mechanical Systems) are miniaturized devices that combine micro-scale mechanical components, sensors, actuators, and electronics on a single chip. In biosensors, MEMS technology is used to build very small and highly sensitive devices for detecting biological or chemical changes. It works by integrating tiny structures (like cantilevers, membranes, or channels) with electronic circuits. These structures respond to physical, chemical, or biological signals and convert them into electrical outputs.

MEMS are widely used in:

- Pressure sensors
- Lab-on-a-chip devices
- Medical diagnostic biosensors
- Drug delivery systems

25. What is conductivity and conductometry?

Conductivity is the property of a solution that allows it to conduct electric current due to the movement of ions. In aqueous solutions, ions such as Na^+, K^+, Cl^-, or H^+ carry the current. The higher the number of free ions, the higher the conductivity of the solution.

Conductometry is an analytical technique used to measure the conductivity of a solution and relate it to chemical or biochemical changes. In biosensors, it is used to detect changes in ion concentration caused by biological reactions.

26. How immunosensors operate?

Immunosensors operate based on the specific binding between an antigen and an antibody. First, a biological recognition element (antibody or antigen) is immobilized on the surface of a transducer (such as electrochemical, optical, or piezoelectric). When a sample containing the target molecule is introduced, the antigen binds specifically with its corresponding antibody, forming an immune complex. This binding event causes a measurable change such as:

- electrical signal (current, voltage, or impedance change)
- optical change (light intensity or SPR angle shift)
- mass change (in piezoelectric sensors)

27. What is the difference between organic and inorganic nanoparticles?

Organic nanoparticles

- Made from carbon-based materials such as polymers, lipids, proteins, or dendrimers
- Biodegradable and generally biocompatible
- Flexible and can be easily modified with biomolecules
- Lower mechanical strength compared to inorganic types
- Used in drug delivery, imaging, and biosensors

Inorganic nanoparticles

- Made from non-carbon materials such as gold, silver, silica, iron oxide, or quantum dots
- Highly stable and strong mechanical properties
- Often have unique optical, electrical, or magnetic properties
- Less biodegradable in many cases
- Commonly used in biosensing, imaging, and diagnostic devices (e.g., gold nanoparticles in optical biosensors)

28. What is photonic immobilization?

Photonic immobilization is a technique used in biosensors where light energy (usually laser or UV light) is used to attach or fix biological molecules (like enzymes, antibodies, or DNA) onto a sensor surface. In this process, the surface is first treated with a light-sensitive material. When light is applied, it activates chemical groups on the surface, allowing covalent bonding between the biomolecule and the support material. This method provides:

- Strong and stable attachment of biomolecules
- Precise control over immobilization area
- Minimal damage to biological activity
- Improved sensitivity and performance of biosensors

29. What are death chills?

Death chills refer to a medical condition in which a person experiences sudden, intense cold sensations accompanied by shivering or trembling as the body approaches severe illness or near-death states. In physiological terms, they occur due to failure of normal body temperature regulation, often caused by severe infection (like sepsis), shock, or organ failure. The nervous system becomes unstable, leading to uncontrolled muscle contractions (shivering) even when the body is not actually cold. In biosensor-related medical monitoring, death chills can be indirectly associated with abnormal physiological signals such as rapid changes in body temperature, heart rate, or metabolic activity, which can be detected by physiological biosensors.

30. What is the impact of pressure on hydrogen bond?

Pressure affects hydrogen bonds by changing the distance and orientation between molecules. When pressure increases, molecules are forced closer together, which can:

- Strengthen hydrogen bonding in some systems due to closer proximity and better alignment
- Or distort and weaken hydrogen bonds if the molecular structure becomes compressed or unstable

In biological systems (important for biosensors), high pressure can:

- Alter protein structure by disrupting hydrogen bonding networks
- Affect enzyme activity and binding interactions
- Change the stability of biomolecules used in sensing

31. What is the ideal method to immobilize cells on solid support material?

The ideal method to immobilize cells on a solid support material in biosensors is entrapment in a polymer matrix (gel immobilization). In this method, living cells are mixed with materials like alginate, agarose, or polyacrylamide, which form a porous gel around them. The cells remain trapped inside but are still able to exchange nutrients and analytes through the pores. This method is preferred because it:

- Maintains high cell viability and activity
- Prevents cells from washing away
- Allows good diffusion of substrates and products
- Provides a stable and reusable sensing system

32. What are the limitations of using CNBr Agarose gel for immobilization technique?

- ***High toxicity of CNBr*** – cyanogen bromide is highly poisonous, so preparation and handling require strict safety conditions, making it unsuitable for routine or large-scale use.
- ***Instability of activated agarose*** – CNBr-activated groups are chemically unstable in water and rapidly hydrolyze, which reduces coupling efficiency if not used immediately.
- ***Short working life*** – the activated gel has a very limited shelf life and must be prepared freshly or stored under strict conditions.
- ***Loss of biomolecule activity*** – covalent binding can sometimes alter the structure of enzymes or proteins, leading to reduced biological activity.
- ***Non-specific adsorption*** – unwanted binding of other molecules may occur, which affects selectivity and accuracy of biosensors.
- ***Cost and handling difficulty*** – preparation is expensive and requires controlled pH and temperature conditions.
- ***Harsh immobilization conditions*** – reaction conditions may not be suitable for sensitive cells or delicate biomolecules, leading to partial denaturation.

33. What are monoclonal antibodies?

Monoclonal antibodies (mAbs) are identical antibodies produced from a single clone of B-lymphocyte cells**.** They are designed to recognize and bind to one specific antigen or epitope. In biosensors, monoclonal antibodies are used as highly specific bioreceptors because they provide accurate and selective detection of target molecules. They are produced using hybridoma technology, where a single antibody-producing cell is fused with a cancer cell to create a long-lived cell line that continuously produces identical antibodies.

34. Define Biotinylation?

Biotinylation is the process of attaching biotin (a small vitamin molecule) to biomolecules such as proteins, antibodies, or nucleic acids through a chemical reaction. In biosensors, this modification is used to improve specific binding and detection efficiency because biotin has a very strong and specific affinity for streptavidin or avidin. This interaction helps in immobilizing biomolecules on sensor surfaces and enhances signal strength and sensitivity in detection systems.

35. Define thermal imaging.

Thermal imaging is a technique used to detect and measure the infrared radiation (heat) emitted by objects or living tissues and convert it into a visible image showing temperature differences. In biosensor and biomedical applications, it helps in identifying abnormal temperature patterns in the body, which can indicate infection, inflammation, or metabolic changes.

36. Write advantages of environmental biosensor.

- High sensitivity, capable of detecting very low levels of pollutants, toxins, and pathogens in environmental samples like air, water, and soil
- High specificity due to biological recognition elements (enzymes, antibodies, or microorganisms), which reduces false detection
- Rapid and real-time monitoring, allowing immediate detection of environmental changes and contamination events
- Cost-effective compared to traditional laboratory-based analytical techniques
- Requires very small sample volumes for analysis
- Portable and suitable for on-site field testing without complex laboratory equipment

37. Enlist components of electron biosensor.

- ***Bioreceptor (biological recognition element)*** – such as enzymes, antibodies, or DNA that specifically interacts with the target analyte
- ***Transducer (electronic component)*** – converts the biological interaction into an electrical signal (can be electrochemical, optical, or piezoelectric based)
- ***Electrodes*** – working, reference, and counter electrodes used to measure the electrical response
- ***Signal processor*** – amplifies and processes the electrical signal into readable data
- ***Display or output system*** – shows the final measured result in digital or analog form

38. Write traditional method in detection of microbes.

- ***Microscopic examination –*** direct observation of microbes using staining techniques like Gram staining
- ***Culture method*** – growing microbes on selective or differential media to identify colonies
- ***Biochemical tests*** – identifying microbes based on metabolic activities (e.g., sugar fermentation, enzyme production)
- ***Serological methods*** – detection using antigen–antibody reactions (e.g., agglutination tests)
- ***Plate count method*** – estimating microbial numbers by counting colonies formed on agar plates
- ***Most Probable Number (MPN) method*** – statistical estimation of microbial concentration in liquid samples

39. What is immobilization and stabilization?

Immobilization is the process of fixing biological molecules such as enzymes, antibodies, or cells onto a solid support material (like beads, membranes, or electrodes) so they remain in place while still retaining their biological activity. It is widely used in biosensors to improve reusability and control the interaction with the target analyte.

Stabilization refers to maintaining or enhancing the structural and functional integrity of immobilized biomolecules so that they remain active for a longer time under working conditions such as changes in temperature, pH, or storage conditions.

40. Write role of Optical biosensor in biometric verification.

Optical biosensors play an important role in biometric verification by using light-based detection methods to identify and authenticate individuals based on their unique biological features. They work by analyzing optical signals such as light absorption, reflection, fluorescence, or refractive index changes from biological traits like fingerprints, iris patterns, facial features, or even skin characteristics. These optical signals are converted into digital data and compared with stored biometric templates for verification. In biometric systems, optical biosensors provide high accuracy and fast response, making them suitable for secure authentication applications such as access control, banking systems, and identity verification.

41. What is quantum dot?

A quantum dot is a very small semiconductor nanoparticle (2–10 nm in size) that has unique optical and electronic properties due to quantum confinement effects. When exposed to light or electrical energy, quantum dots can emit light of specific colors depending on their size. Smaller dots emit blue light, while larger dots emit red light. In biosensors, quantum dots are used as fluorescent labels because they provide high brightness, stability, and sensitivity for detecting biological molecules such as proteins, DNA, or cells.

42. Why biosensors are used to detect the shortage of water in plants?

Biosensors are used to detect water shortage in plants because they can monitor physiological and biochemical changes that occur during water stress. When plants face water deficiency, they show changes such as increased levels of stress hormones (like abscisic acid), changes in leaf temperature, reduced stomatal activity, and altered ion balance. Biosensors can detect these signals quickly and accurately. They provide real-time monitoring of plant water status, allowing early detection of drought stress before visible symptoms appear. This helps in efficient irrigation management, improves crop yield, and conserves water.

43. Write note on biosensor in blood glucose.

A blood glucose biosensor is a medical biosensor used to measure the concentration of glucose in blood, mainly for diabetes monitoring. It works using an enzyme-based bioreceptor, most commonly glucose oxidase (GOx). When a blood sample is applied, glucose reacts with the enzyme and produces products such as gluconic acid and hydrogen peroxide. This biochemical reaction generates an electrical signal (current, voltage, or oxygen change), which is detected by the transducer and converted into a digital glucose reading. Blood glucose biosensors provide fast, accurate, and portable testing, allowing patients to monitor glucose levels regularly without laboratory analysis.

44. Explain Biophotonics.

Biophotonics is the study and application of light (photons) interacting with biological materials such as cells, tissues, and biomolecules. In biosensors, it uses optical techniques like laser light, fluorescence, scattering, and absorption to detect and analyze biological processes. When light interacts with a biological sample, it produces signals that can be measured to identify changes in structure, composition, or concentration of biomolecules. Biophotonics is widely used in medical diagnostics and biosensing because it is non-invasive, highly sensitive, and allows real-time analysis of biological systems.

45. What is collagen?

Collagen is a structural protein found in animals that forms the main component of connective tissues such as skin, tendons, cartilage, bones, and blood vessels. It provides strength, elasticity, and support to tissues. Collagen molecules are arranged in a triple-helix structure, which makes them very strong and stable. In biosensors, collagen is often used as a biocompatible material for cell culture and immobilization matrices because it supports cell attachment and mimics natural biological environments.

46. What is enzyme printed electrode?

An enzyme printed electrode is an electrode in which a specific enzyme is directly immobilized or printed onto the electrode surface to act as a biological recognition element in a biosensor. When the target analyte comes in contact with the enzyme layer, a biochemical reaction occurs, producing measurable products such as electrons, ions, or hydrogen peroxide. The electrode then converts this reaction into an electrical signal (current or voltage). These electrodes are commonly used in screen-printed biosensors, especially for glucose and other metabolite detection, because they are low-cost, disposable, and suitable for mass production.

47. What are first generation problems of biosensors?

The first-generation biosensors (especially enzyme-based electrochemical biosensors like early glucose sensors) had several limitations:

- They depended on natural oxygen as a co-substrate, so sensor performance was affected by oxygen concentration in the sample
- Produced interference from other electroactive substances (such as ascorbic acid or uric acid), reducing accuracy
- Had limited sensitivity and slower response time compared to modern biosensors
- Required strict operating conditions like controlled pH and temperature for enzyme stability
- Showed poor long-term stability due to enzyme degradation over time
- Provided less precise measurements in complex biological samples like blood or serum

48. Explain working of blood pressure apparatus.

A blood pressure apparatus (sphygmomanometer) works by measuring the pressure of blood against the walls of arteries, usually the brachial artery in the arm. First, an inflatable cuff is wrapped around the upper arm and connected to a pump and pressure gauge. The cuff is inflated to apply pressure, which temporarily stops blood flow in the artery. Then the air is slowly released. As pressure decreases, blood starts flowing again through the artery. During this process, a stethoscope or pressure sensor detects Korotkoff sounds or pressure changes. The point where the first sound is heard represents systolic pressure, and the point where the sound disappears represents diastolic pressure. In electronic versions used in biosensors, pressure sensors directly detect arterial pulsations and convert them into digital blood pressure readings without using a stethoscope.

49. What type of detection is performed by environmental biosensors?

Environmental biosensors perform detection of biological, chemical, and toxic pollutants in the environment. They are used for:

- Detection of water pollutants such as heavy metals, pesticides, and organic toxins
- Detection of air pollutants like harmful gases (CO, NO_2, SO_2) and volatile compounds
- Detection of soil contamination including industrial chemicals and pathogens
- Detection of microorganisms such as bacteria, viruses, and other pathogens in environmental samples

50. Write properties of glassy carbons.

- High electrical conductivity, making it suitable for electrochemical biosensors
- Chemically inert and corrosion-resistant, stable in harsh chemical environments
- High thermal stability, can withstand high temperatures without degradation
- Smooth, non-porous surface with good mechanical strength
- Wide potential window, allowing detection of various electrochemical reactions
- Low background current, which improves signal sensitivity and accuracy
- Biocompatible surface, suitable for enzyme and biomolecule immobilization

51. What Lateral Flow Immunoassay (LFI)?

A Lateral Flow Immunoassay (LFI) is a simple, paper-based biosensor technique used to detect the presence of a specific target such as antigens, antibodies, or other biomolecules in a liquid sample. It works by allowing the sample to move along a strip through capillary action. As the sample flows, it interacts with immobilized antibodies or antigens on the strip. If the target molecule is present, it forms a visible complex, often shown as a colored line. LFI is widely used in rapid diagnostic tests such as pregnancy tests, COVID-19 tests, and infectious disease screening due to its speed, low cost, and ease of use.

52. What is cholesterol? Write its importance.

Cholesterol is a type of lipid (fat-like substance) found in the blood and all body cells. It is produced mainly by the liver and is also obtained from certain foods.

Importance of cholesterol:

- It is a structural component of cell membranes, helping maintain their stability and fluidity
- It is required for the synthesis of hormones such as estrogen, testosterone, and cortisol
- It helps in the production of vitamin D in the body
- It is essential for the formation of bile acids, which aid in fat digestion
- It plays a role in nerve function and brain development

53. What is the clinical use of Xanthine oxidase?

Xanthine oxidase is an enzyme used in clinical biosensors mainly for the detection and measurement of xanthine and uric acid levels in biological samples. Its clinical uses include:

- Diagnosis and monitoring of gout, as it is related to uric acid production
- Assessment of purine metabolism disorders
- Detection of kidney function problems, since uric acid is excreted through kidneys
- Used in biosensors to measure xanthine levels in food and biological fluids, helping in metabolic studies

54. Write applications of Nucleic Acid-Base biosensor.

- Detection of specific DNA or RNA sequences for genetic analysis
- Diagnosis of infectious diseases by identifying pathogen genetic material (viruses, bacteria)
- Identification of genetic disorders and mutations such as cancer-related gene changes
- Used in forensic science for DNA fingerprinting and criminal identification
- Monitoring of food safety by detecting contamination from genetically modified organisms (GMOs) or pathogens
- Applications in environmental monitoring to detect microbial contamination in water and soil
- Used in drug development and pharmacogenetics for personalized medicine approaches

55. What is Impedance plethysmography (IPG)?

Impedance Plethysmography (IPG) is a non-invasive technique used to measure changes in blood volume or blood flow in a body part by detecting variations in its electrical impedance. It works by passing a small, safe alternating electrical current through tissue using surface electrodes. As blood volume in the area changes (for example, during heartbeats or vascular activity), the electrical impedance of the tissue also changes. These variations are recorded and analyzed. In biosensor applications, IPG is commonly used to monitor:

- Blood flow in limbs
- Cardiac output and heart activity
- Detection of vascular disorders and circulation problems

56. How gold nanoparticles are formed?

Gold nanoparticles are formed by reducing gold ions (Au^{3+}) into elemental gold (Au^0) in a controlled chemical process. A common method is the chemical reduction method. First, a gold salt such as chloroauric acid ($HAuCl_4$) is dissolved in water, which provides gold ions. Then a reducing agent (such as sodium citrate or sodium borohydride) is added. This converts gold ions into tiny gold atoms, which start clustering together to form nanoparticles. At the same time, a stabilizing agent (often the same citrate or other capping molecules) prevents the particles from growing too large and keeps them evenly dispersed. The size and shape of the gold nanoparticles depend on reaction conditions like concentration, temperature, and type of reducing agent. In biosensors, they are used because of their strong optical properties and ability to enhance signal detection.

57. What is DNA microarray?

A DNA microarray is a biosensor-based tool used to analyze thousands of DNA sequences simultaneously on a small solid surface such as a glass slide or silicon chip. It consists of a grid of many tiny spots, each containing a specific single-stranded DNA probe. When a sample containing fluorescently labeled DNA or RNA is applied, it hybridizes (binds) with complementary sequences on the chip. The binding pattern is detected using a laser scanner or optical system, which shows which genes are present or active. DNA microarrays are widely used for:

- Gene expression analysis
- Detection of genetic disorders
- Cancer research
- Identification of infectious agents
- Drug response and personalized medicine studies