Roll No. | | | | |

Internal Assessment Test 2 – Jan 2025

Sub:	Applied Chemistry for CSE				Sub Code:	BCHES102	Branch:	CSE & CS-AIDS
Date:	17-01-2025	Duration:	90 min's	Max Marks: 50	Sem / Sec:	I / I, J, K & L		OBE

Question no. 1 is COMPULSORY and answer any THREE FULL Questions from the rest.

		MARKS	CO	RBT
1 (a)	What are sensors? Explain the working principle of electrochemical gas sensors for the detection of SOx and NOx.	[7]	CO4	L3
(b)	Define photoactive and electroactive materials and explain their working principle in the display system.	[7]	CO1	L3
2 (a)	Explain organic memory devices of p-type and n-type semiconducting materials by taking suitable examples.	[6]	CO1	L2
(b)	Define liquid crystals. Describe the classification of liquid crystals with suitable examples.	[6]	CO1	L2
3 (a)	What are Memory Devices? Classify the electronic memory devices and discuss any 2 types in detail.	[6]	CO1	L2
(b)	Explain any four properties and applications of light emitting material, Poly [9-vinyl carbazole] (PVK) suitable for optoelectronic devices.	[6]	CO1	L1
4 (a)	What are OLED? Discuss their properties and applications.	[6]	CO1	L1
(b)	Explain the applications of Liquid crystals in LCD's (Display) with the help of suitable diagram.	[6]	CO1	L3
5 (a)	Discuss different stakeholders involved in environmental management of e-waste and their responsibilities.	[6]	CO3	L2
(b)	Explain extraction of gold from e-waste, and mention its benefits.	[6]	CO3	L3
6 (a)	Discuss the pyrometallurgy and hydrometallurgy method of recycling of E-waste.	[6]	CO3	L2
(b)	Mention toxic materials used in the manufacturing of electronic and electrical products, and discuss their health hazards.	[6]	CO3	L1
7 (a)	What is an optical sensor? Explain its working principle and mention its applications.	[6]	CO4	L2
(b)	What is a thermometric sensor? Discuss its working principle and 4 applications.	[6]	CO4	L2
8 (a)	What are disposable sensor? Explain the principle of the disposable sensor in the detection of glyphosphate.	[6]	CO4	L2
(b)	Explain the detection of pharmaceutical pollutant diclofenac using electrochemical sensor.	[6]	CO4	L2

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1a.

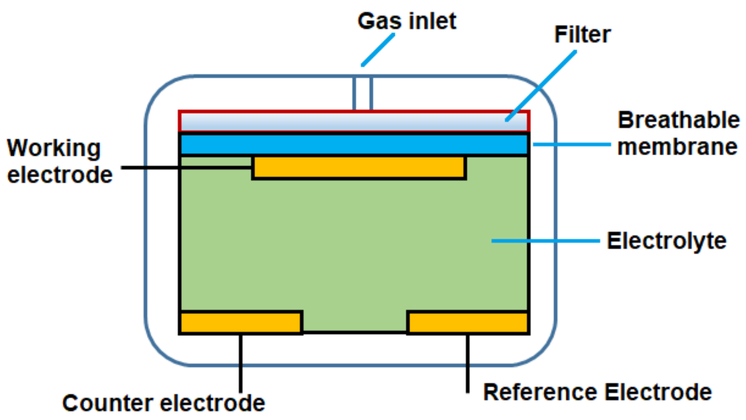
A sensor is a device that can detect or measure a physical input (stimulus) from the environment by converting it into an electrical signal which can be read by an instrument.

<u>Construction</u>

- ***Working electrode*** (sensing electrode): **Gold**
- ***Counter electrode***: **Platinum**
- ***Reference electrode***: **Ag/AgCl**
- ***Electrolyte***: ionically conducting materials (**3-7M H_2SO_4**)
- ***Membrane***: A gas-permeable membrane is used to control the gas flow reaching the electrode surface.
- ***Filter:*** to filter out the unwanted gas

<u>Working</u>

- The electrodes are separated and immersed in an aqueous medium (electrolyte).
- The gas molecules diffuse through a porous membrane that is placed in contact with the working electrode.
- In this electrode surface, gas molecules lose electrons after the oxidation process.
- A reduction of oxygen occurs at the counter electrode in electrochemical sensors.
- Electrons move through wires connected to the electrodes and an external circuit.
- Flow of electrons generates an electrical signal proportional to the concentration of toxic gas.
- The medium provides hydrogen ions (H^+) that move through the aqueous solution



<u>Electrochemical reactions</u> for the SO_2 and NO gas sensors are:

Working electrode (Anode): $SO_2 + H_2O \rightarrow SO_3 + 2\,H^+ + 2\,e^-$
Counter electrode (Cathode): $(1/2)\,O_2 + 2\,H^+ + 2\,e^- \rightarrow H_2O$

Working electrode (Anode): $NO + H_2O \rightarrow NO_2 + 2\,H^+ + 2\,e^-$
Counter electrode (Cathode): $(1/2)\,O_2 + 2\,H^+ + 2\,e^- \rightarrow H_2O$

2a.

<u>Photoactive materials</u>: Photoactive materials are those materials that can absorb light energy and undergo a photochemical reaction. They are used in photovoltaic cells which convert sunlight into electrical energy.
Examples: Silicon

<u>Working principle</u>

- **Absorption**: Photoactive materials must be able to absorb light energy in order to generate excited states.
- **Excited states**: After absorbing the light, it undergoes a photochemical reaction that generates excited states. These excited states are unstable and can decay back to the ground state by emitting light.
- **Energy transfer**: Excited states can transfer energy to other molecules, either within the same material or to a different material. This energy transfer can lead to the generation of electrical or chemical energy.

<u>Electroactive materials:</u> Electroactive materials are those materials that can conduct electricity and exhibit changes in their electrical properties in response to an external electric field.

Examples: Conductive polymers

<u>Working principle</u>

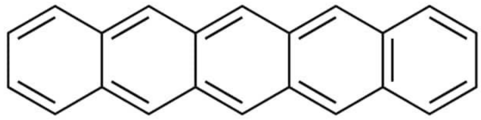
The principles that govern electroactive materials are based on the *interaction between the material and the electrical field*.

- **Conductivity**: Electroactive materials must be able to conduct electrical current in order to respond to an external electrical stimulus through the electrons or ions.
- **Response time**: Electroactive materials must be able to respond quickly to changes in the electrical field. The response time is determined by the mobility of the charge carriers.
- **Electrical properties**: The electrical properties of the material, such as its resistivity, permittivity, and capacitance, determine how it will respond to an external electrical stimulus.

2.a

Organic memory devices use p-type and n-type semiconductor materials to create a heterojunction that can be used to store data.

<u>p-type semiconductors materials</u> that have an excess of positively charged holes, which can conduct electricity. *Examples*: Pentacene.



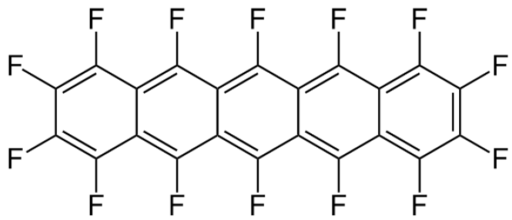
Application: It is used in organic flash memory and organic resistive random access memory (RRAM).

<u>Characteristics</u>

- It has **high hole mobility**, which makes it a good material for organic memory devices.
- It has a **low ionization potential**,
- It is highly **sensitive to light** and has **high photoconductivity**.
- It has a **long carrier diffusion length**.
- It is a **stable material**.

<u>n-type semiconductor materials</u> that have an excess of electrons in their conduction band.

Examples: Perfluoropentacene.



Application: It is used in the construction of organic electronic devices such as organic field-effect transistors.

<u>Characteristics</u>

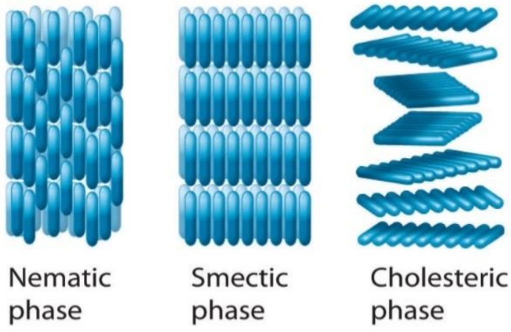
- It has **high electron mobility**, which allows electrons to move quickly through the material.
- It has a **high electron affinity**
- It is a **stable material**
- It has **low ionization potential.**
- It is **highly sensitive to light** and has **high photoconductivity**.

2.b

Liquid Crystal: An ordered fluid mesophase of an organic long-chain molecules possessing both solid-like molecular order and liquid-like character is known as a liquid Crystal.

Classification

A. **Thermotropic liquid crystals:** When long-chain organic solids are heated, they undergo sharp phase transitions at a particular temperature yielding liquid crystals.



Thermotropic liquid crystals are three types:

1. **Nematic:** The molecules move either sideways or up and down. In this case, the molecules are readily aligned in the same direction in the presence of ***electric and magnetic fields***. The alignment of molecules is ***temperature sensitive***.

Example: p-azoxyphenetole,

2. **Smectic:** The molecules in smectic crystals are oriented parallel to each other as in the nematic phase but in layers. These layers can pass on each other because the force between the layers is weak.

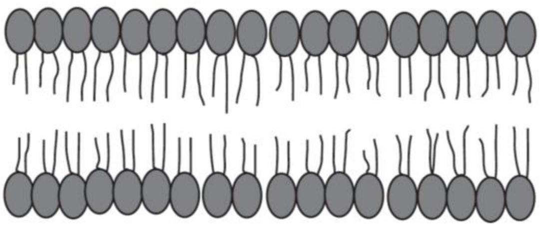
Example: smectic–A (*SmA*)

3. **Cholesteric:** The molecules in successive layers are slightly twisted or rotated with respect to the layers above and below to form a continuous helical or spiral pattern.

Example: Cholesteryl benzoate

B. **Lyotropic liquid crystals:** The orientational behaviour of lyotropic crystals is a function of concentration and solvent. These molecules are amphiphilic in nature–they have both hydrophilic and hydrophobic ends in their molecules. At low concentrations, these molecules are randomly oriented but as the concentration increases, the molecules start arranging themselves.

Example: Cell membranes



3.a

Memory devices are electronic components that can store and retrieve digital data. These devices are used to hold data and programs that a computer needs to access quickly.

<u>Classification of electronic memory devices</u>

A. **<u>Transistor type electronic memory devices</u>:** Such type memory device uses transistors as the building blocks for data. The basic principle of transistor-type electronic memory is that it stores data as charges on the gates of transistors, which act as switches. The data can be read from the transistor by measuring the voltage level on the gate.

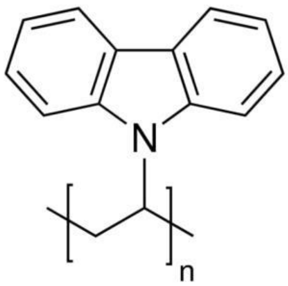
Examples: Dynamic Random Access Memory (DRAM), Static Random Access Memory (SRAM)

B. **<u>Capacitor type electronic memory devices</u>:** Such type memory device uses capacitors to store digital data. The basic principle of capacitor type electronic memory is that it stores data as electrical charge on a capacitor. When the data needs to be read, the charge on the capacitor is measured and translated into a digital value.

Examples: NAND Flash Memory, Ferroelectric RAM (FeRAM)

3.b

Poly (9-vinylcarbazole) (PVK) is a light-emitting material which is used in optoelectronic devices due to its desirable properties.



<u>Properties</u>

- PVK has a **high optical transparency** in the visible range, which makes it suitable for use as a transparent electrode in optoelectronic devices.
- PVK has **good charge transport properties**, allowing for efficient movement of electrons and holes through the polymer.
- PVK has **high thermal stability**, which means that it can withstand high temperatures without degradation.
- PVK is **soluble in common organic solvents**, such as chloroform and toluene, which makes it easy to process and fabricate into thin films for use in optoelectronic devices.

<u>Applications</u>

- PVK can be used as a hole transport layer in **organic light-emitting diodes**.
- PVK can be used as a hole-transporting material in **organic photovoltaic devices**.
- PVK can serve as an active material in **photodetectors**, converting incoming light into electrical signals.

- PVK-based devices can be used as **sensors** for detecting various environmental factors, including temperature, humidity, and gas concentrations.

4.a

Organic Light-Emitting Diode (OLED) is a type of display technology that utilizes organic materials to emit light when an electric current is applied.

<u>Properties of OLEDs</u>

- OLEDs are very **thin and flexible**, which makes them suitable for use in curved or flexible displays.
- OLEDs have a **high contrast** ratio i.e.; they can produce deep black and bright white images.
- OLEDs have a **fast response time** i.e.; they can switch on and off quickly, resulting in smooth video content.
- OLEDs have a **wide viewing angle** i.e.; the image quality is maintained even when viewed from different angles.
- OLEDs are **energy efficient**, as they do not require a backlight resulting in lower power consumption.

<u>Applications of OLEDs</u>

- OLED displays are used in **televisions, monitors, smartphones, and other electronic devices**.
- OLED displays are used as a **lighting source** in various applications, including automotive lighting, street lighting, and architectural lighting.
- OLEDs can be used in **automotive applications**, such as dashboard displays, interior lighting, and taillights.
- OLEDs can be used in **medical applications**, such as in surgical lighting and medical imaging.

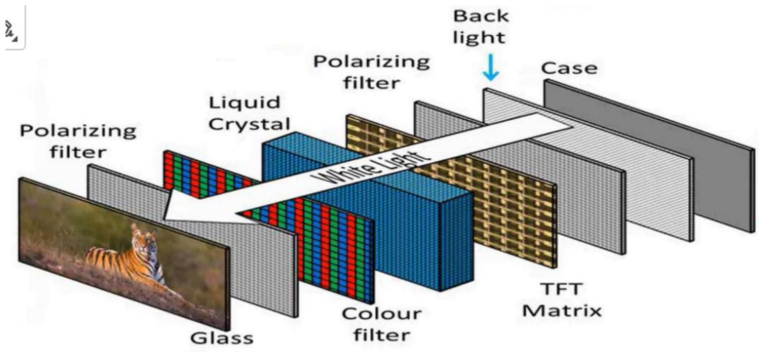
4.b

Liquid crystal display: A liquid crystal display (LCD) is a flat panel display technology that uses liquid crystals to produce images. They are commonly used in electronic devices such as televisions, computer monitors and mobile phones.

<u>Working of LCD</u>

- The working principle of an LCD is based on the **optical properties** of liquid crystals (LC).
- A layer of LC material is sandwiched between **two polarizing filters** to control the orientation of the light passing through it.
- It has a **backlight**, which shines light through the LC layer to produce an image.

- Each pixel of an LCD contains **three sub-pixels** that can produce red, green, and blue colors. By adjusting the voltage applied to each sub-pixel, the LCD can create millions of different colors.
- When the orientation of the liquid crystal molecules is aligned with the direction of the polarizing filters, light can pass through the filters and the liquid crystal layer, creating a **bright pixel**.
- After applying an electric field, the orientation of the LC molecules changes, and they no longer align with the polarizing filters. This causes the light passing through the LC layer to be blocked, creating a **dark pixel**.
- By controlling the orientation of the LC molecules with an electric field, an image can be formed by selectively **allowing or blocking** light through different pixels in the display.



5.a

In of e-waste management, the following stakeholders play an important unique role:

1. Producers

Producers have a responsibility to design and produce products that are environmentally friendly and can be easily recycled or reused at the end of their useful lives. They should also participate in e-waste collection and recycling programs and contribute to the development of sustainable e-waste management systems

2. Consumers

Consumers play a critical role in reducing e-waste by choosing to purchase products that are designed to be environmentally friendly, and by properly disposing of their old electronics. Consumers can also participate in e-waste collection and recycling programs and can advocate for the development of more sustainable e-waste management systems.

3. Recyclers

Recyclers and waste management companies are responsible for collecting, treating, and disposing of e-waste in a safe and responsible manner. They should use environmentally friendly methods for extracting valuable materials from e-waste, and should properly dispose of any hazardous waste generated during the process.

4. Statutory bodies

Statutory bodies such as governments, are responsible for creating and enforcing regulations and policies to manage e-waste and promoting public awareness and education about e-waste management.

5.b

<u>Principle:</u>

The principle behind the extraction of gold from e-waste is that gold is a relatively non-reactive metal, which allows it to be recovered from complex electronic waste matrices through a series of chemical and physical processes.

<u>Experimental procedure</u>:

1. ***Collection and segregation of e-waste***: The first step involves collecting and segregating the e-waste into different categories, such as computer motherboards, cell phones, and other electronic devices.
2. ***Physical separation***: The e-waste is physically separated into different components, such as plastics, metals, and glass.
3. ***Leaching***: The metals, including gold, are leached from the e-waste using a suitable reagent, such as aqua regia (a mixture of hydrochloric acid and nitric acid), to dissolve the gold.

$$Au + HNO_3 + 4HCl \rightarrow HAuCl_4 + NO + 2H_2O$$

4. **Precipitation**: The dissolved gold is then precipitated out of the solution through the addition of a suitable reducing agent, such as sodium metabisulfite.

$$2H[AuCl_4] + 3Na_2S_2O_5 + 3H_2O \rightarrow 2Au + 3SO_2 + 3Na_2SO_4 + 8HCl$$

5. **Purification**: The precipitated gold is then purified through processes such as ion exchange, electro-winning, or distillation, to remove impurities and improve its quality.
6. **Recovery**: The purified gold is then recovered for reuse.

6.a

Hydrometallurgical extraction:

Hydrometallurgical extraction is a process used to extract valuable metals and minerals from electronic waste using chemical reactions and water-based solutions. This process involves the following steps:

- **Collection and sorting**: Electronic waste is collected and sorted into different categories based on the materials present.
- **Shredding or grinding**: The electronic waste is shredded or ground into small particles to increase the surface area for the extraction process.
- **Leaching**: The crushed electronic waste is then treated with a solution, such as sulfuric acid, that dissolves the metals and minerals. This solution is referred to as the leachant.
- **Separation**: The metal-rich solution is then separated from the solid waste. The metals and minerals present in the solution are then recovered using a variety of techniques, such as precipitation, ion exchange, and solvent extraction.
- **Purification**: The recovered metals and minerals are then purified to remove impurities.

Pyrometallurgical methods:

Pyrometallurgical methods of e-waste recycling involve the use of high temperatures to extract metals and minerals from electronic waste. The following are the steps involved in a typical pyrometallurgical process:

- **Collection and sorting**: Electronic waste is collected and sorted into different categories based on the materials present.
- **Shredding or grinding**: The electronic waste is shredded or ground into small particles to increase the surface area for the extraction process.
- **Smelting**: The shredded electronic waste is then heated in a furnace, along with a fluxing agent, to extract the metals. The fluxing agent helps to separate the metals from the other components of the waste.
- **Separation**: The melted waste is then cooled, and the metals are separated from the slag (non-metallic waste) using a variety of techniques, such as skimming, tapping, and slag fuming.
- **Purification**: The extracted metals are then purified to remove impurities.

6.b

<u>Toxic materials</u>

a) **Lead** is a toxic heavy metal commonly used in batteries, computer monitors, and other electronic components.

a) **Mercury** is used in some fluorescent lights, batteries, and other electronic devices.

b) **Cadmium** is a toxic heavy metal used in rechargeable batteries, pigments, and plastic stabilizers.

c) **Polyvinyl Chloride (PVC)** is used in electronic cables, which release toxic chemicals, such as dioxins, when burned or during disposal.
d) **Brominated flame retardants (BFRs)** are toxic and can harm the environment and human health.
e) **Lithium** is used in rechargeable batteries, but it can be toxic if not handled properly.

<u>Health hazardous</u>

a) **Poisoning:** Toxic substances, such as lead, cadmium, and mercury can cause poisoning if they enter the body.
b) **Respiratory problems:** Exposure to dust and fumes generated can cause respiratory problems, such as asthma and bronchitis.
c) **Neurological effects:** Toxic substances such as lead and mercury, can cause neurological effects, including memory loss.
d) **Reproductive problems:** toxic substances such as cadmium, can cause reproductive problems.
e) **Cancer:** Exposure to carcinogenic substances, such as dioxins and polychlorinated biphenyls (PCBs), found in e-waste, can increase the risk of cancer.

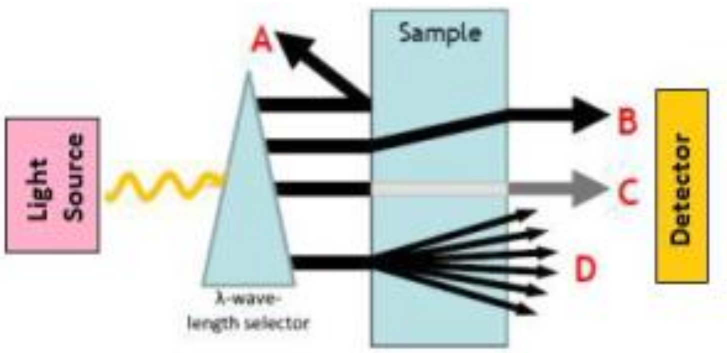
7.a

Optical sensor

An optical sensor is a device that can detect light, typically at a specific range of electromagnetic spectrum (ultraviolet, visible, and infrared). This sensor can detects various properties of light such as intensity, wavelength, frequency or polarization of light and converts it into an electric signal.

Working principle optical sensor

- ***Transmitter (Light Source)***: Optical sensors have a light source that emits light. This source can be an LED (Light-Emitting Diode) or laser diode.
- ***Interaction with Target***: The emitted light interacts with the target or the environment. This interaction involves reflection, absorption, transmission, scattering, or diffraction of light by the target.
- ***Light Detection (Receiver)***: Optical sensors have a light detector, which can be a photodiode. The detector can sense the change in the properties of the light.
- ***Conversion to Electrical Signal***: The light detector converts the detected optical signals into electrical signals. The amount of change in the electrical signal is related to the properties of the light interacting with the target.



Applications

- The following are the applications of optical sensors:
- It is used in remote sensing satellite
- Used in imaging
- Quality and Process Control applications.

7.b

Thermometric sensor

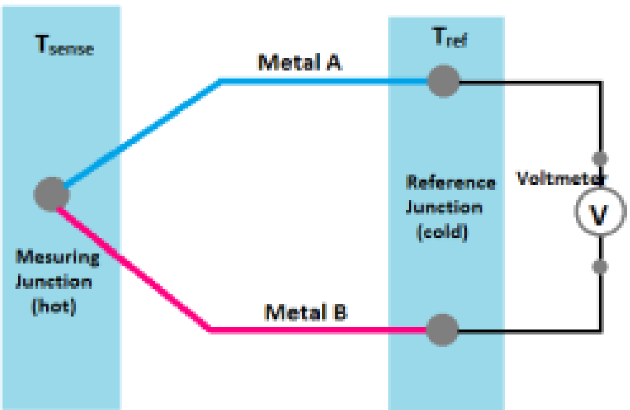
A temperature sensor is a device, typically, a thermocouple or resistance temperature detector, that provides temperature measurement in a readable form through an electrical signal.

Working principle of thermometric sensors

The working principle of a thermometric sensor is based on the concept that the physical properties of materials change with temperature. They are composed of two dissimilar metals that generate an electrical voltage or resistance when a temperature change occurs by measuring the voltage across the diode terminals.

- ***Thermocouples***

In this case, when there is a temperature gradient between the measuring junction and reference junction, a voltage is generated. The magnitude of this voltage depends on the temperature difference between the two junctions and the types of metals used in the thermocouple.



Applications

- Used for verifying design and construction.
- Used to measure the temperature rise during the process of curing concrete.
- They can measure rock temperatures near liquid gas storage tanks
- It can measure water temperatures in reservoirs and boreholes.

8a.

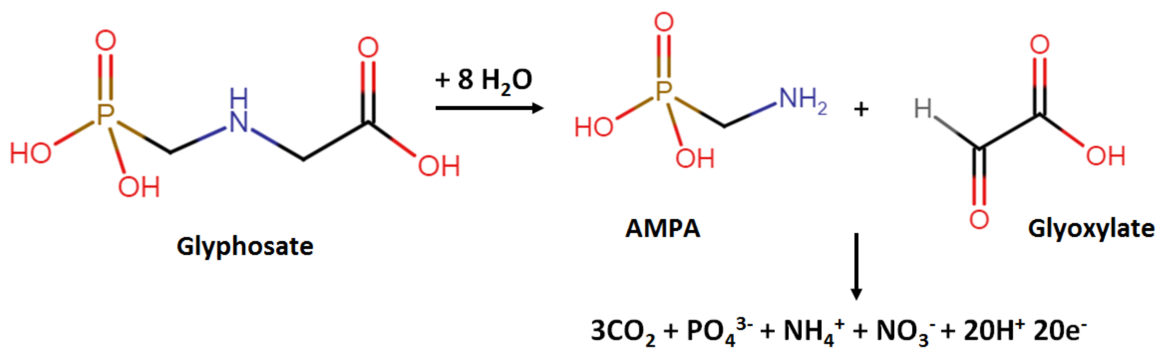
Disposable sensors are low-cost and easy-to-use sensing devices intended for short-term or rapid single-point measurements.

Construction

- The sensor is a silicon-based chip comprising of three-electrode system.
- ***Working Electrode***: A gold electrode of 4 mm diameter coated with ***200nm*** thickness gold nanoparticles.
- ***Counter electrode***: A gold electrode of 4 mm diameter coated with ***20nm*** thickness gold nanoparticles.
- ***Reference Electrode***: Ag/AgCl

Working

- The electrochemical detection is based on the oxidation of Glyphosate on gold working electrode.
- A potential of 0.78V is applied on working electrode, there is an interaction between analyte and electrode surface.
- Glyphosate oxidizes on the working electrode brings a change in current in the electrolyte medium.
- The change in the current is a measure of concentration of Glyphosate



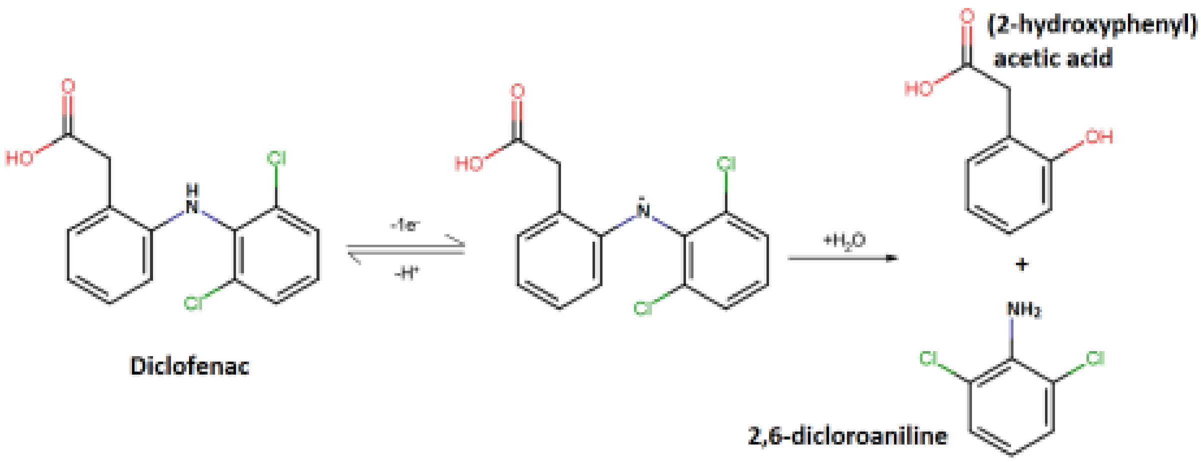
8.b

Construction

- Working electrode: Carbon coated with MWCNT
- Counter Electrode: Platinum mesh (Pt)
- Reference Electrode: Ag/AgCl
- Electrolyte : Aqueous solution of LiCl salt

Working

- When electrochemical sensor is immersed into the sample containing diclofenac drug compound (pH 7.2), an electrochemical oxidation of diclofenac occurs on the surface of the working electrode to which a potential is applied with respect to the reference electrode while the corresponding current is measured.
- The change in potential of the reaction gives the concentration of diclofenac.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N
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Diclofenac
2,6-dicloroaniline