CMR
INSTITUTE OF
TECHNOLOGY

IAT 3 - Scheme of Evaluation

Internal Assessment Test 3 – April 2023									
Sub:	**Applied Chemistry for CSE**		Sub Code:	**BCHES102**			Branch:	CSE & CSE(DS)	
Date:	03-01-2024	Duration:	90 mins	Max Marks:	50	Sem:	I	Section:	I,J, K & L

	<u>**Question no. 1 is COMPULSORY and answer any THREE FULL Questions from the rest**</u>	Marks
1 (a)	**What are batteries? Explain the construction and working of Li-ion batteries and mention its applications.** Definition Diagram Construction Working Applications	**(7 M)** 1 M 1 M 2 M 2 M 1 M
(b)	**What are Memory Devices? Briefly explain the classification of memory device.** Definition Description with examples.	**(7 M)** 1 M (1.5 * 4) M
2 (a)	**Explain any four properties and applications of Polythiophenes (P3HT) suitable for optoelectronic devices.** Any four properties Any four applications	**(6 M)** 3 M 3 M
(b)	**Define liquid crystals? Describe the classification of liquid crystals with suitable examples.** Definition Classification (3 type) with example	**(6 M)** 1 M 5 M
3(a)	**What are photoactive and electroactive materials? Explain their working principle in display system.** Definition of photoactive and electroactive Diagram Working principle.	**(6 M)** 2 M 2 M 2 M
(b)	**Explain any four properties and applications of light emitting material, Poly [9-vinyl carbazole] (PVK) suitable for optoelectronic devices.** Any four properties Any four applications	**(6 M)** 3 M 3 M
4(a)	**Explain working principle, properties and applications of Quantum dot sensitized solar cell.** Definition Diagram Construction & working Applications	**(6 M)** 1 M 1 M 3 M 1M
(b)	**Explain organic memory devices of p-type and n-type semiconducting materials by taking suitable examples.** Eg and Structure of p-type and n-type material Working principle and diagram	**(6 M)** (2+2) M (1+1) M
5 (a)	**What are OLED? Discuss their properties and applications.** Definition Properties (Minimum 4) Applications (Minimum 4)	**(6 M)** 1 M 3 M 2 M
(b)	**Explain the applications of Liquid crystals in LCD's (Display) with the help of suitable diagram.** Detailed description of application in LCD Diagram	**(6 M)** 4 M 2 M
6 (a)	**Discuss the different roles of stakeholders in the environmental management of e-waste.** Mention all the stake holder Explanation about all the five types of stake holders	**(6 M)** 1 M 5 M
(b)	**Discuss in detail the process of extraction of gold from e-waste with suitable reactions.** Explanation on 5 steps involve in gold extraction Reactions	**(6 M)** 4 M 2 M

7 (a)	**Explain the charge transfer mechanism taking place in polyimide polymeric material for Organic memory device.** Structure of polyimide Donor –acceptor Diagram Mechanism description	**(6 M)** 1 M 1 M 2 M 2 M
(b)	**What are light emitting electrochemical cell? Discuss any 4 properties and applications of LEC.** Definition Properties (Minimum 4) Applications (Minimum 4)	**(6 M)** 1M 3 M 2 M

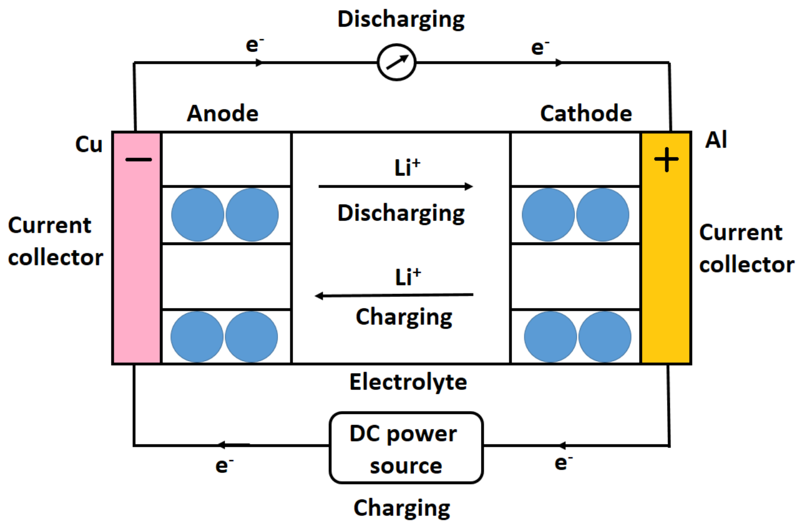
(Chief Course Instructor)

1.a. What are batteries? Explain the construction and working of Li-ion batteries and mention its applications.

Battery is a device that converts chemical energy directly into electrical energy via electrochemical oxidation and reduction reaction.

Li-ion battery

Li-ion battery is a type of rechargeable battery that uses lithium ions as the primary carrier of electric charge. The movement of lithium-ion takes place through the electrolyte from one electrode to another electrode.



Construction

- ***Anode***: Lithium intercalated graphite layer (Li_xC_6)
- ***Cathode***: Partially lithiated transition metal oxide, E.g. Lithium cobalt oxide ($LiCoO_2$)
- ***Electrolyte***: Lithium salts like LiCl, LiBr dissolved in propylene carbonate
- ***Separator***: Polyolefin polymer

Working

- Anode reaction: $Li_xC_6 \longrightarrow xLi^+ + xe^- + 6C$
- Cathode reaction: $Li_{1-x}CoO_2 + xLi^+ + xe^- \longrightarrow LiCoO_2$
- Overall reaction: $Li_{1-x}CoO_2 + Li_xC_6 \longrightarrow LiCoO_2 + 6C$

During ***discharge***, Li^+ ions are dissociated from the anode and then migrate from the anode to cathode through the electrolyte. Electrons travel through an external circuit. This process creates an electric current that can power a device or system.

*During **Charging:*** Li^+ ions move from the cathode to the anode through the electrolyte.

Application of Lithium-ion battery

- They are commonly used in smart phones, tablets, laptops

- They are used in medical devices
- They are used in spacecraft and satellites
- They are used in electric cars.

2.a. What are Memory Devices? Briefly explain the classification of memory device.

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.

Classification of electronic memory devices

A. **Transistor type electronic memory devices:** 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. **Capacitor type electronic memory devices:** 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)

C. **Resistor type electronic memory devices:** Such type memory device store the digital data using the resistance of a material. The basic principle is that it stores data as the resistance level of a resistor. The data can be read by measuring the resistance of each resistor.

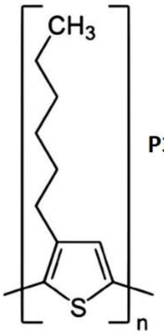
Examples: Resistive Random Access Memory (RRAM), Phase-Change Memory (PCM)

D. **Charge transfer type electronic memory devices:** Such type memory devices use the transfer of charge between capacitors or other circuit elements to store and retrieve digital data. The data can be read by measuring the voltage level on the capacitor or other element.

Examples: Charge-Coupled Device (CCD) Memory, Ferroelectric Random Access Memory (FRAM)

2.a Explain any four properties and applications of Polythiophenes (P3HT) suitable for optoelectronic devices.

It is a semiconducting polymer, an excellent candidate for optoelectronic devices.



P3HT: Poly(3-hexylthiophene)

Properties of polythiophenes:

- They have **high charge carrier mobility**, which is crucial for efficient charge transport in optoelectronic devices.
- They are **highly soluble** in common organic solvents, making them easy to process into thin films required for optoelectronic devices.
- They have a **high absorption coefficient** in the visible range, which allows them to absorb light in solar cells and photodetectors efficiently.
- They have **tunable optical and electrical properties** which allows them for specific optoelectronic applications.

Applications

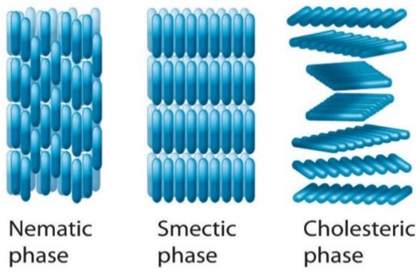
- These materials are used as active layers in **organic solar cells**.
- These materials are used in the fabrication of **Organic Light-Emitting Diodes** as emissive or charge-transporting layers.
- These materials are used in **photodetectors** to sense light and convert it into an electrical signal.
- These materials are incorporated into field-effect transistors (FETs) to create **Light-Emitting Transistors**.
- These materials are also used as sensing elements in various types of **sensors**.

2.b. Define liquid crystals? Describe the classification of liquid crystals with suitable examples.

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. **<u>Nematic</u>:** 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. **<u>Smectic</u>:** 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.

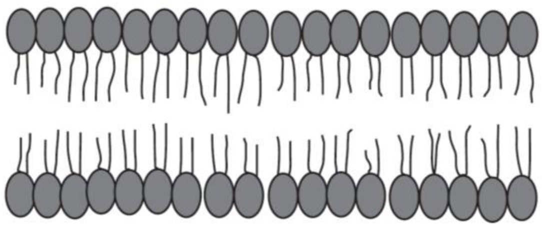
Example: smectic–A (*SmA*)

3. **<u>Cholesteric</u>:** 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. <u>Lyotropic liquid crystals:</u> 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. What are photoactive and electroactive materials? Explain their working principle in display system.

<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.

Electroactive materials: 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

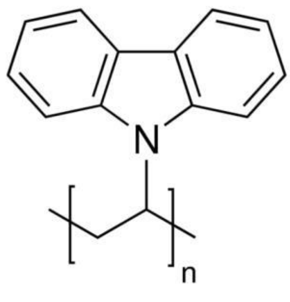
Working principle

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.

3.b. Explain any four properties and applications of light emitting material, Poly [9-vinyl carbazole] (PVK) suitable for optoelectronic devices.

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



Properties

- 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.

Applications

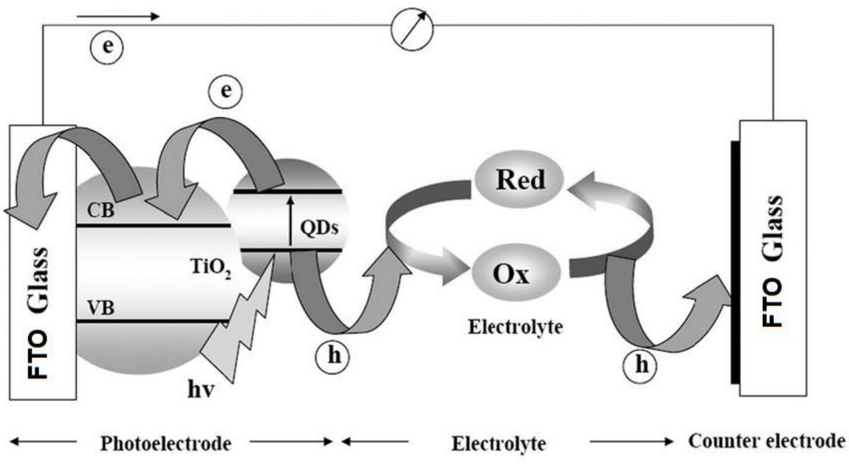
- PVK can be used as a hole transport layer in **organic light-emitting diodes**.
- PVK can be used as a hole-transporting material in **organic photovoltaic devices**.
- PVK can serve as an active material in **photodetectors**, converting incoming light into electrical signals.
- PVK-based devices can be used as **sensors** for detecting various environmental factors, including temperature, humidity, and gas concentrations.

4.a. Explain working principle, properties and applications of Quantum dot sensitized solar cell.

A quantum dot solar cell (QDSC) is a type of solar cell that utilizes quantum dots as a light-absorbing material to convert sunlight into electricity.

Construction

- ***Transparent conducting electrode***: FTO glass (Fluorine-doped Tin Oxide)
- ***Transparent Conductive Oxide Layer***: TiO_2 film
- ***Quantum dots layer***: Light-absorbing semiconductor materials (CdSe or CdS)
- ***Electrolyte***: Polysulphide is used as a redox electrolyte.
- ***Counter Electrode***: used to complete the circuit and helps to generate electricity.



Working

a) Upon absorption of a photon, a quantum dot is excited from the ground state (QDS) to a higher energy state (QDS*)

Excitation process: QDs + $h\nu \rightarrow$ QDs*

b) The absorption process results in the creation of electron-hole pair in the form of the ***exciton***. Dissociation of the exciton occurs if the thermal energy exceeds its binding energy

Exciton dissociation: QDs* → e- + h+* (free energy)

c) The excited electron is then injected in the conduction band of the wide bandgap semiconductor nanostructured TiO_2 thin film. This process will cause the oxidation of the photosensitizer

Injection process: QDs* + TiO_2 → TiO_2e^{-}* + QDs^{+}

d) The injected electron is transported between the TiO_2 nanoparticles, and then gets extracted to a load where the work done is delivered as electrical energy.

Energy generation: TiO_2e-* + C.E → TiO_2 + e* (CE)

Properties:

- Quantum dots have tunable bandgap which allow to absorb light across a broader spectrum of wavelengths, increasing efficiency.
- Quantum dots can generate multiple excitons from a single high-energy photon, enhancing the current output compared to traditional solar cells.
- Quantum dots exhibit enhanced light absorption which enabling them to capture more sunlight than bulk materials.
- Quantum dot solar cells have shown potential for high conversion efficiencies.

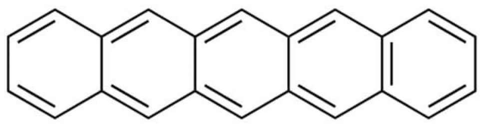
Applications

- It is used as light-emitting Diodes
- It is used as a photoconductor and photodetector
- It is used as a photovoltaic
- It is used in biomedicine and environment.

4.b. Explain organic memory devices of p-type and n-type semiconducting materials by taking suitable examples.

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

p-type semiconductors materials 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).

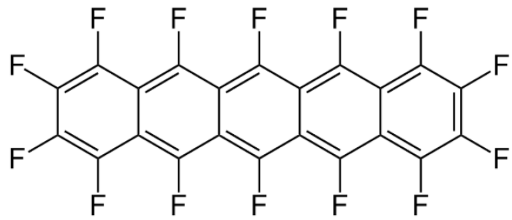
Characteristics

- 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**.

n-type semiconductor materials 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.

Characteristics

- 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**.

5.a. What are OLED? Discuss their properties and applications.

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

Properties of OLEDs

- 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.

Applications of OLEDs

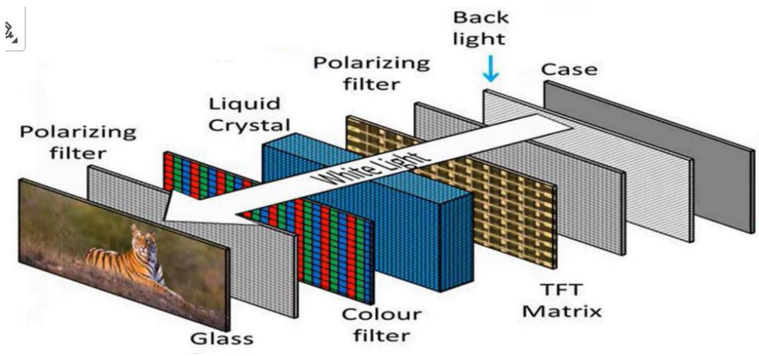
- OLED displays are used in **televisions, monitors, smartphones, and other electronic devices**.
- OLED displays are used as a **lighting source** in various applications, including automotive lighting, street lighting, and architectural lighting.
- OLEDs can be used in **automotive applications**,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

5.b. Explain the applications of Liquid crystals in LCD's (Display) with the help of suitable diagram.

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.

Working of LCD

- 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.



6.a. Discuss the different roles of stakeholders in the environmental management of e-waste.

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.

6.b. Discuss in detail the process of extraction of gold from e-waste with suitable reactions.

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.

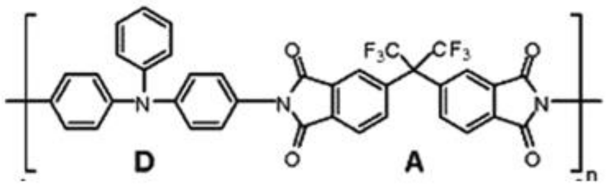
$$2\ H[AuCl_4] + 3Na_2S_2O_5 + 3H_2O \rightarrow 2Au + 3SO_2 + 3Na_2SO_4 + 8HCl$$

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.

7.a. Explain organic memory devices of polymeric materials by taking an examples of polyimides.

Polyimide-based polymeric materials have found several applications in the field of organic memory devices.

Example:



As shown in figure, the functional TP6F-PI contains triphenylamine as electron donor and phthalimide as the acceptor to form a D–A structure. The hexafluoroisopropylidene (6F) group plays an important role in organic memory devices.

Advantages:

- **Dielectric Material**: Polyimides can serve as an insulating dielectric material in organic memory devices.
- **Charge Storage**: Polyimides can be functionalized or engineered to incorporate charge storage sites or traps. These traps can capture and hold charges, representing the 0s and 1s of digital data.
- **Non-volatile Memory**: Organic memory devices using polyimide dielectrics can function as non-volatile memory, where data is retained without the need for a continuous power supply.
- **Low Power Consumption**: Organic memory devices, with polyimide components, often have lower power consumption compared to traditional silicon-based memory devices.
- **Cost-Effective Production**: Polyimides can be processed using cost-effective techniques like spin coating or solution casting.

7.b. What are light emitting electrochemical cell? Discuss any 4 properties and applications of LEC.

A **light-emitting electrochemical cell** (LEC) is a type of device where organic semiconductor material is used as light-emitting layer to ***generate light using electrochemical processes***.

Properties of LEC

- LECs can be fabricated using simple and **low-cost methods**.
- LECs can exhibit **high internal quantum efficiency**.
- LECs can operate at low voltages, typically below 5V, which can **reduce power consumption**.
- The **emission properties** of LECs can be tuned by varying the composition and thickness of the light-emitting layer.

Applications of LEC

- LECs can be used to produce bright and **energy-efficient lighting sources**.
- LECs can be used to create **flexible and lightweight displays**, including large-area displays.
- LECs can be used as **sensors** for detecting gases, biological molecules, and other analytes.
- LECs can be used to produce **electricity from sunlight**.
- LECs are used in **medical applications**, such as in wearable devices.