IAT 3 Solution BCHES202 September 2023

Internal Assessment Test 3 – September 2023

Sub:	Applied Chemistry for CSE					Sub Code:	BCHES202	Branch:	ISE, AIML, AI&DS, CS-AIML
Date:	05-09-2023	Duration:	90 min's	Max Marks:	50	Sem / Sec:	II / A,B,C, D, E, F & G		OBE

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

			MARKS	CO	RBT
1	(a)	What is direct recycling approach? Discuss in detail the process of extraction of gold from e-waste.	[7]	CO3	L2
	(b)	Define liquid crystals. Describe the classification of liquid crystals with suitable examples.	[7]	CO1	L2
2	(a)	Define photoactive and electroactive materials? Explain their working principle for display system.	[6]	CO1	L3
	(b)	Explain any four properties and applications of Polythiophenes (P3HT) suitable for optoelectronic devices.	[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)	What are OLED? Discuss their properties and applications.	[6]	CO1	L2
4	(a)	What are light emitting electrochemical cell? Discuss any 4 properties and applications of LEC.	[6]	CO1	L2
	(b)	Explain the types of organic memory devices by taking P-type and n-type semiconducting materials.	[6]	CO1	L3
5	(a)	Discuss the properties of liquid crystal and explain its applications in LCD's (Liquid crystal display) with the help of suitable diagram.	[6]	CO1	L3
	(b)	What are nanomaterials? Discuss any four properties and applications of silicon nanocrystals (SiNCs) suitable for optoelectronic devices.	[6]	CO1	L2
6	(a)	What are the diffrerent approaches of recycling of e-waste? Describe any 2 methods in detail.	[6]	CO3	L2
	(b)	Discuss the different roles of stakeholders in the environmental management of e-waste.	[6]	CO3	L1
7	(a)	Explain any four properties and applications of light emitting material, Poly [9-vinyl carbazole] (PVK) suitable for optoelectronic devices.	[6]	CO1	L2
	(b)	Explain the charge transfer mechanism taking place in polyimide polymeric material for Organic memory device.	[6]	CO1	L3

Answer 1a: **Direct recycling of e waste:**

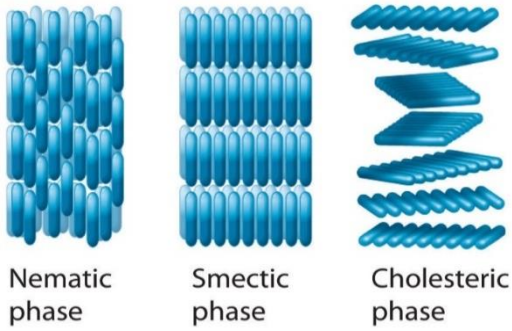
Direct recycling of e-waste refers to the process of recovering valuable materials from electronic waste without the need for intermediate processing steps. This can include processes such as **shredding, granulating, and sorting**, which are used to separate the different components of e-waste, such as metals, plastics, and glass. The separated materials are then processed to extract the valuable components and prepare them for reuse.

Extraction of gold from e-waste (Explain the Principle and experimental procedure):

Principle: The principle behind the extraction of gold from e-waste is based on the fact 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.
Experimental procedure:
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.

Answer 1b: **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.

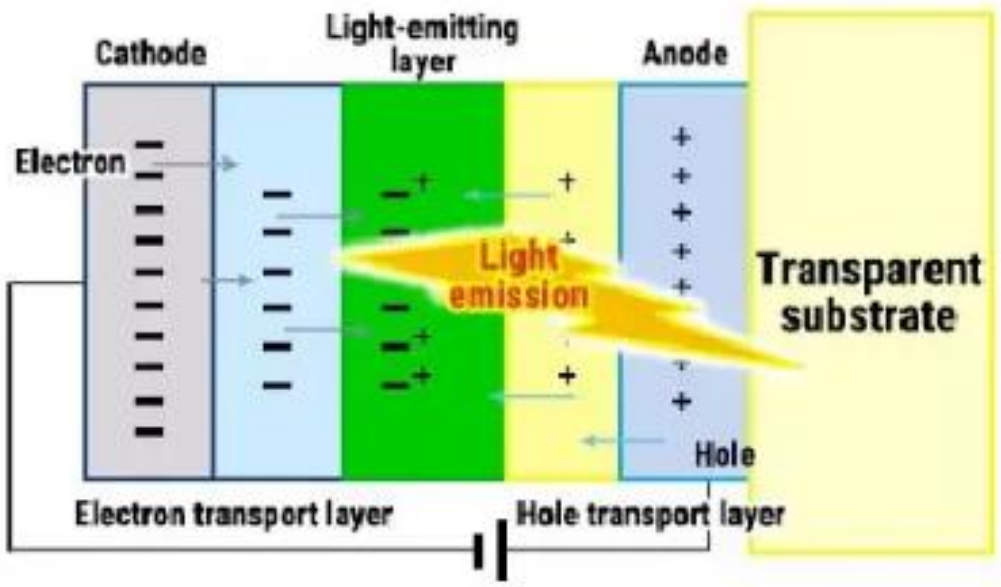
Example: Cholesteryl benzoate

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

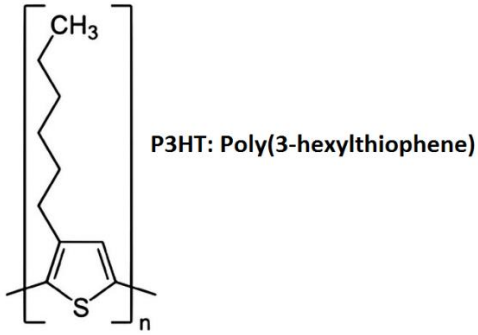
Answer 2a: Photoactive and electro active organic materials: Photoactive and electroactive organic materials are the semiconductors composed of π-electron systems which are used in electronic and optoelectronic devices

Working principle: Photoactive and electroactive material absorb and emit light in the UV to IR region. Display system (OLED) consisting of photoactive and electroactive material absorb light and allows an electron to jump from HOMO of a Donor to LUMO of an Acceptor. This phenomenon generate and transport charge carriers. In an OLED device, the light-emitting layer is excited by the recombination energy of electrons from the cathode and holes from the anode, and then the light-emitting layer emits light when returning to the ground state. One of the electrodes consists of transparent material in order to extract light from the light emitting layer.



Answer 2b:

Polythiophene: 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**.

Answer 3a: 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.

Answer 3b: 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.

Answer 4a 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

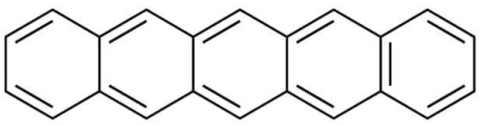
- LECs can be fabricated using simple and **low-cost methods**.
- LECs can exhibit **high internal quantum efficiency**.
- LECs can operate at low voltages, typically below 5V, which can **reduce power consumption**.
- The **emission properties** of LECs can be tuned by varying the composition and thickness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

Answer 4b: Organic memory devices use p-type and n-type semiconductor materials to create a heterojunction that can be used to store data.

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

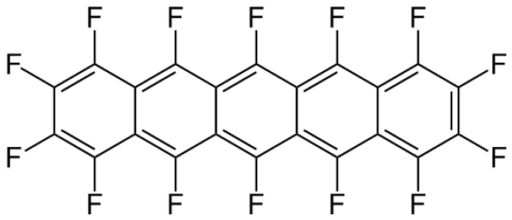


Application: It is used in organic flash memory and organic resistive random access memory (RRAM).

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**.

B. **<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**.

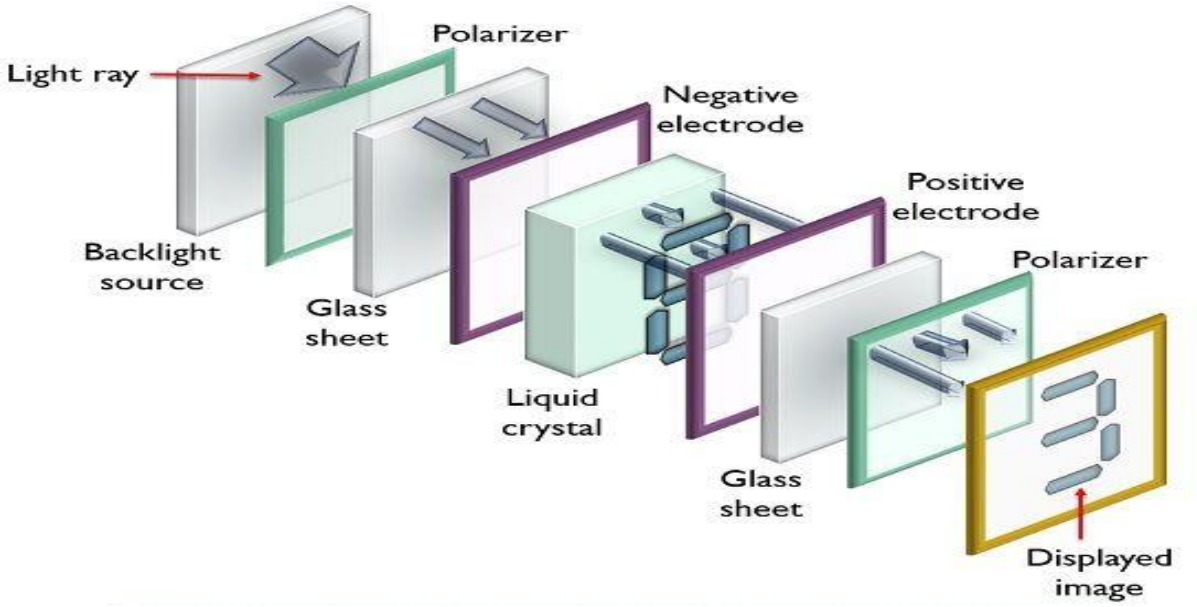
Answer 5a: **<u>Properties of Liquid Crystals</u>**

- Liquid crystals are **anisotropic**, i.e., they exhibit different properties in different directions.
- Liquid crystals are **birefringent**, i.e., they can split light into two polarized components.
- Some liquid crystals are **optically active**, i.e., they rotate the polarization of light.
- Liquid crystals exhibit **phase transitions** with changes in temperature and pressure.
- Liquid crystals can be **sensitive to external fields**, such as electric or magnetic fields, which can affect their orientation and properties.

<u>Application of LCs in 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.



Answer 5b: Nanomaterials are commonly defined as materials with an average particle size of less than 100 nm. They exhibit unique physical and chemical properties that differ from their bulk counterparts.

Silicon nanocrystals (SiNCs) are nanometer-sized clusters of silicon atoms that exhibit unique properties due to their small size and quantum confinement effects.

Properties of SiNCs

- The **optical properties** of SiNCs are highly dependent on their size. Varying particle size leads to tunable optical properties.
- SiNCs exhibit **photoluminescence**, which means they can absorb photons and re-emit them as light.
- Silicon nanocrystals can have enhanced **carrier mobility** compared to bulk silicon due to the reduced scattering of charge carriers at the nanoscale.
- SiNCs can exhibit **good stability** against **photobleaching**.

Applications of SiNCs

Silicon nanocrystals (SiNCs) have various optoelectronic applications due to their unique optical and electronic properties.

- SiNCs are incorporated into **Light Emitting Diodes** (LEDs) to create efficient and tunable light sources.
- SiNCs enhance the efficiency of **solar cells** by extending the absorption spectrum of silicon to longer wavelengths.
- SiNCs are used as active materials in **photodetectors** to convert light signals into electrical signals.
- SiNCs are also used in **optical modulators** to control the intensity, phase, or polarization of light signals.

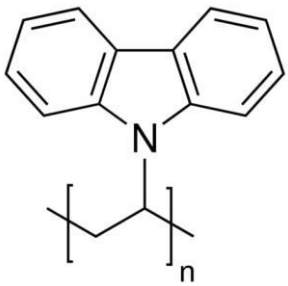
Answer 6a: E-Waste recycling and recovery can be achieved through different approaches, including separation and thermal treatments.
Separation: This involves physically separating different components of e-waste, such as metals, plastics, and circuit boards.
Thermal treatments: ***E-waste thermal treatment refers to the use of high temperatures to recover valuable metals and other materials from electronic waste***. This process can include ***incineration or other pyrometallurgical techniques***.

Hydrometallurgical extraction of E waste:
E-waste hydrometallurgical extraction is a process used to extract valuablemetals and other materials from electronic waste through chemical reactions in aqueous solutions. The process typically involves the following steps:
Pre-treatment: This involves the fragmentation and size reduction of electronic waste to prepare it for further processing.
1. Leaching: The e-waste is treated with chemical reagents in a solution to dissolve the metals and other materials, creating a leachate.
2. Separation: The leachate is then processed to separate and purify the metals and other materials, through methods such as precipitation or ion exchange.
3. Recovery: The extracted metals and other materials are then recovered and processed for reuse.

Pyrometallurgical methods E-waste recycling:
E-waste pyrometallurgical methods refer to the process of extracting valuable metals and other materials from electronic waste using high temperatures. These methods include:
1. Smelting: The e-waste is melted in a furnace and then separated into individual metals and other materials.
2. Refining: The metals from the smelted e-waste are further processed to remove impurities and improve their quality.
3. Incineration: Electronic waste is burned at high temperatures to reduce its volume and recover metals.

Answer 6b: In the management of electronic waste (e-waste), the following stakeholders play important unique role in the management of e-waste:
1. **Producers** - are responsible for designing and producing electronic products and may also be involved in the collection and recycling of e-waste.
2. **Consumers** - play a crucial role in the responsible disposal of e-waste and making informed choices about the purchase of electronic products.
3. **Recyclers** - are responsible for safely and responsibly managing e-waste, including the collection, dismantling, and recycling of electronic waste.
4. **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.

Answer 7a: 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.

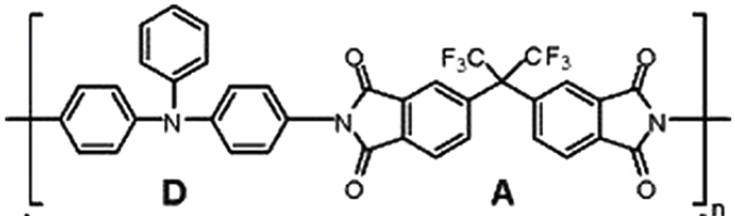
- PVK has **good charge transport properties**, allowing for efficient movement of electrons and holes through the polymer.
- PVK has **high thermal stability**, which means that it can withstand high temperatures without degradation.
- PVK is **soluble in common organic solvents**, such as chloroform 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.

Answer 7b: PolymericMolecules Polymer used for organic memory device is Polyimide (PI) with Donor- Triphenylamine and Acceptor- phthalimide.

- This polymer has high thermal stability and mechanical strength.
- The donors and acceptors of PIs contribute to the electronic transition based on an induced charge transfer (CT) effect under an applied electric field.
- Hexafluoroisopropylidene (6F): Increases the solubility of PI



Mechanism:
When an electric field more than threshold energy is applied, the electrons of the HOMO (TPA unit) is excited to LUMO. LUMO of donor and acceptor are similar and therefore, after excitation the electron transferred to LUMO(acceptor), generating a CT state. This permits the generation of holes in the HOMO, which produces the open channel for the charge carriers to migrate through. Therefore, Field-induced charge transfer from triphenylamine to phthalimide exhibit the switchingbehavior (bistable states ON/OFF)