GUDLAVALLERU ENGINEERING COLLEGE

(An Autonomous Institute with Permanent Affiliation to JNTUK, Kakinada)

Seshadri Rao Knowledge Village, Gudlavalleru – 521 356.

Department of Computer Science and Engineering

HANDOUT

on

CHEMISTRY

Vision :

To be a Centre of Excellence in computer science and engineering education and training to meet the challenging needs of the industry and society

Mission:

- To impart quality education through well-designed curriculum in tune with the growing software needs of the industry.
- To be a Centre of Excellence in computer science and engineering education and training to meet the challenging needs of the industry and society.
- To serve our students by inculcating in them problem solving, leadership, teamwork skills and the value of commitment to quality, ethical behavior & respect for others.
- To foster industry-academia relationship for mutual benefit and growth

Program Educational Objectives :

PEO1: Identify, analyze, formulate and solve Computer Science and Engineering problems both independently and in a team environment by using the appropriate modern tools.

PEO2: Manage software projects with significant technical, legal, ethical, social,environmental and economic considerations.

PEO3: Demonstrate commitment and progress in lifelong learning, professional development, Leadership and Communicate effectively with professional clients and the public

HANDOUT ON CHEMISTRY

Class & Semester: I B.Tech – I Semester Year:2018-19

Branch: CSE Credits : 4

1. Brief history and current developments in the subject area

Chemistry is the study of matter, its properties and the changes that it may undergo and how these properties and changes are affected by its composition. It is important for engineers to have knowledge of chemistry, since they can expect to find problems in fields as diverse as the design and development of new materials, quality control and environmental engineering that are basically chemical in nature.

Chemistry is the back bone in designing and understanding the nature of various engineering materials. Many advances in engineering either produce a new chemical demand as in the case of polymers or wait upon chemical developments for their application as in the case of implants and alloys. Currently, the electronics and computers engineers are waiting for suitable biopolymers and nano-molecules for use in miniature super computers; the electrical engineers are in search of proper conducting polymers; the mechanical engineers are on look out for micro fluids and the civil engineers are looking for materials that are environment friendly, economical but long lasting.

2. Pre-requisites, if any

- Basic Knowledge of Chemistry at Intermediate Level is required.

3. Course objectives:

- To impart the knowledge in chemistry and applications of nano materials, liquid crystals and polymers used in engineering.
- To impart knowledge in chemistry of semiconductors, batteries and to impart the knowledge of green chemistry in green synthesis of products.

4. Course outcomes:

At the end of the course, Students will be able to

- CO1: explain the synthesis, properties and applications of nano materials.
- CO2: analyse the principles in working of LCD, sensors and bio sensors.
- CO3: Explain the preparation, properties and applications of polymers.
- CO4: explain the characteristics of super conducting materials and non-elemental semiconductors.
- CO5: analyse the working principles of batteries, fuel cells and solar

cells.

- CO6: explain the principles of green chemistry and suitable methods for synthesis of green products.

5. Program Outcomes:

Graduates of the Computer Science and Engineering Program will have

a) an ability to apply knowledge of mathematics, science, and engineering
b) an ability to design and conduct experiments, as well as to analyze and interpret data
c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
d) an ability to function on multidisciplinary teams
e) an ability to identify, formulate, and solve engineering problems
f) an understanding of professional and ethical responsibility
g) an ability to communicate effectively
h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
i) a recognition of the need for, and an ability to engage in life-long learning,
j) a knowledge of contemporary issues
k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

6. Mapping of Course Outcomes with Program Outcomes:

	a	b	c	d	e	f	g	h	i	j	K	l
CO1	L	H	H		H			L			H	
CO2	H				L			H	L			
CO3	H	H	H		L							
CO4	H	H			L			H				
CO5	H	H	L		L			H			H	
CO6	H	H	H		H			H			H	

7. Prescribed Text books

- Text book of Engineering Chemistry by Jain & Jain. Dhanpat Rai Publishing Company, 16^{th} Edn.,2015.
- A Text book of Engineering Chemistry by Shashi Chawla. Dhanpat Rai Publications, 3^{rd} Edn.,2013.

8. Reference books

- A Text book of Engineering Chemistry by S.S.Dara. S.Chand & Company Ltd., 12^{th}Edn.,2010.
- Engineering Chemistry by J.C.Kurisascose and J.Rajaram. volumes

1&2,Tata Mc Graw-Hill Publishing.

9. Lecture Schedule / Lesson Plan

S.No	TOPIC	No of. Periods	No of. Tutorials
	UNIT-I :		
1.	Introduction	1	2
2.	Basic concepts of nano materials.	1	
3.	Different types of nano materials.	1	
4.	Synthesis of nano materials by sol-gel method.	1	
5.	Determination of thin film nanomaterials by chemical vapour deposition method.	1	2
6.	Definition and types of carbon nano tubes with diagrams.	1	
7.	Method of preparation of carbon nano tubes by Arc discharge method only.	1	
8.	Properties and applications of CNTs.	1	
9.	Definition and applications of quantum dots.	1	
	UNIT-II :		
10.	Definition and types of liquid crystals	1	2
11.	Properties and engineering applications of liquid crystals.	1	
12.	Working principle of Liquid Crystal Display (LCD) with diagram.	1	
13.	Working principle of OLED with diagram.	1	
14.	Working principle of compact disc and pen drive.	1	
15.	Principles of sensors and biosensors.	1	2
16.	Description of electrochemical sensors and its applications.	1	
17.	Working principle of glucometer.	1	
18.	Engineering applications of bio-sensors.	1	
	UNIT-III :		
19.	Concept and definition of matrix and reinforcement.	1	2
20.	Types of fibre reinforced plastics (Glass Fibres, Carbon fibres, aramid fibres).	1	
21.	Preparation methods of fibre reinforced plastics (hand layup method, matched metal die moulding method).	1	
22.	Properties and engineering applications of fibre reinforced plastics.	1	
23.	Definition and types of conducting Polymers.	1	2
24.	Properties and engineering applications of conducting Polymers.	1	
25.	Concept and definition of Bio-Degradable Polymers.	1	
26.	Preparation, properties and applications of Dacron and	1	

	PHBV.		
27.	Concept and definition of matrix and reinforcement.	1	
	UNIT-IV :		
28.	Concepts of Non-Elemental Semiconductors & Super Conductivity.	1	2
29.	Stoichiometric semiconductors.	1	
30.	Non- Stoichiometric semiconductors.	1	
31.	Controlled valency semi conductors.	1	
32.	Preparation of ultrapure Si and Ge.	1	2
33.	Introduction and definition of super conductors.	1	
34.	Types of superconductors.	1	
35.	Preparation of 1-2-3 super conducting pellet and classes of super conductors.	1	
36.	Properties and engineering applications of super conductors.	1	
	UNIT-V :		
37.	Concepts related to energy storage devices.	1	2
38.	Definition of secondary cell with example.	1	
39.	Construction, electro chemical reactions and applications of Lithium ion battery.	1	
40.	Construction, electro chemical reactions and applications of Pb-acid storage battery.	1	
41.	Maintenance free lead acid battery. Definition of fuel cell.	1	
42.	Construction, electro chemical reactions and applications of H_2-O_2 fuel cell.	1	
43.	Construction, electro chemical reactions and applications of Methanol-oxygen fuel cell.	1	2
44.	Origen and concept of solar energy.	1	
45.	Working principle of Photovoltaic cell with diagram.	1	
46.	Working principle of Photosensitizing diode.	1	
47.	Working principle of solar reflectors (parabolic trough, solar dish, and solar tower).	1	
48.	Concepts related to energy storage devices.	1	
	UNIT-VI :		
49.	Concept and need of Green Chemistry	1	2
50.	Principles of Green Chemistry.	2	
51.	Methods of Green synthesis (supercritical fluid extraction, microwave induced methods).	3	2
52.	E-waste management.	2	
53.	Zero Waste Technology.	1	
54.	**Total**	56	12

10. URLs and other e-learning resources

So net CDs &IIT CDs on some of the topics are available in the Digital Library.

11. Digital Learning Materials:

12. Seminars / group discussions, if any and their schedule: Nil

CHEMISTRY

UNIT-1

Nano materials

Objective:

- ➢ To impart knowledge of different preparation methods of nano materials.
- ➢ To impart knowledge of properties, applications of carbon nano tubes (CNTs), and quantum dots.

Syllabus:

Concept of Nano materials –types of nanomaterials – synthesis of nano materials – Sol-gel method, Thin films by Chemical vapour deposition method, Carbon nano tubes(CNTs) – types, preparation of carbon nano tubes by arc discharge method. Properties and applications of CNTs, Quantum dots – applications.

Outcomes: After learning this unit, students will be able to

1. Understand different types of nano materials.
2. Explain the synthesis of nano materials by sol-gel method, chemical vapour deposition method.
3. Express different types of carbon nano tubes and preparation of carbon nano tubes by arc discharge method.
4. Understand properties and applications of CNTs and Quantum dots.

INTRODUCTION:

- Nano materials are expected to have a wide range of applications in various fields such as electronics, optical communications and biological systems.
- These applications are based on factors such as their physical properties, large surface area and small size which offer possibilities for manipulation and room for accommodating multiple functionalities.
- A very promising and rapidly growing field of application of nanotechnology is in medicine. They would possibly repair the metabolic and genetic defects.

Some examples are given below:

- **Nanomaterials** were developed for low-cost filters to provide clean drinking water.
- **Nanomaterials** were developed the super strong materials, super Slippery Materials, tissue engineering, drug delivery, sensors.

- **Nanomaterials** were developed tiny machines in our body for curing cancer.
- **Nanomaterials** were developed the **space elevator**, which is an ultra high strength materials allow tower to be built into space.
- **Nanomaterials** were developed for sensors to detect and identify harmful chemical and biological agents; and Techniques to clean up harmful chemicals in the environment.
- **Nanomaterials** were developed for medical devices and drugs to detect and treat diseases more effectively with fewer side effects.
- **Nanostructured semiconductors** are used as window layers in solar cells.
- **Nanostructured metal-oxide** (MnO2) finds application for rechargeable batteries for cars or consumer goods.
- **The term Nano originated from the Greek word nanos, which means "dwarf" or extremely small and means one billionth (10^{-9}) part of a unit.**

1nm = 10^{-9} meters = 10^{-3} μm = $10A^0$

DAFINATIONS:

Nano Science:-Nano science is the study of nanomaterials,their properties and related phenomena.

Nanotechnology: Nanotechnology is the art and science of manipulating matter at the nanoscale (down to 1/100,000. the width of a human hair) to create new and unique materials and products with enormous potential to change society.

(or)

Nanotechnology is the application of nanoscience to produce devices and products.

Nanoparticals:-Nanoparticals are the particles within the size ranging from

1-50nm.

Nanomaterials:-Nanomaterials are the materials having components within size less then 100nm at least in one dimension.

1nm = 10^{-9} meter

- Let us compare different units with respect to meters.
  1 centimeter – 1,00th of a meter
  1 millimeter – 1,000th of a meter
  1 micrometer – 1,000,000th of a meter
  1 nanometer – 1,000,000,000th of a meter
- Nanomaterials have a **large surface area** but their volume is very small.

- Nanomaterials have high melting point compounds.

Sizes of various objects to have a visual perception of nano-sized objects.

- Human hair is about 100000nm wide.
- Red blood cell is about 2000-5000 nm wide.
- Human DNA is 2.5 nm wide.
- Diameter of carbon nanotube is 1.0-1.3 nm.
- Water molecule is about 0.3 nm across.

Quantum dot:-A quantum dot is a particle having an approximate size of one nanometer which has the display properties of semiconductor.

Or

Quantum dots are semiconductors whose conducting characteristics are closely related to the size and shape of the individual crystal

Ex: Silicon is one of the most popular materials used in creating quantum dot.

TYPES OF NANOMATERIALS:-

Classification is based on the number of dimensions, which are not confined to the nanoscale range (<100).

1) One-dimensional (1-D)
2) Two-dimensional (2-D)
3) Three-dimensional (3-D)

1. One-dimensional nanomaterials:

➢ In this type, only one dimension is confined and the other two are free to move for the electrons.(or)

It has only one parameter either length (or) breadth (or) height.

Examples: thin films or surface coatings.

2. Two-dimensional nanomaterials:

➢ In this type, only one dimension is free to move and two dimensions are confined for electrons.(or)

It has only two parameters either length and breadth (or)breadth and height (or)length and height .

Examples: carbon nano tubes and nano wires.

3. Three-dimensional nanomaterials:

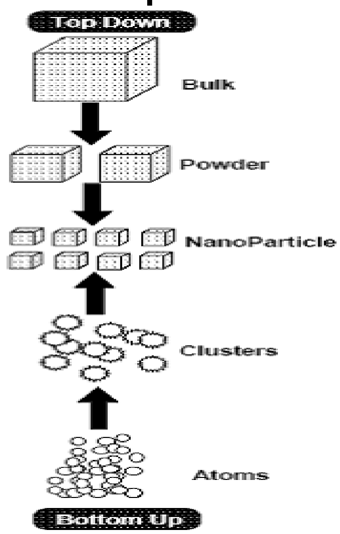
- In three dimensional nano materials, all the three dimensions are confined for electrons.(or)

  It has all parameters of length, breadth and height.

  Examples: particles like precipitates, colloids, fullerenes and quantum dots.

SYNTHESIS OF NANO MATERIALS:

The synthesis of nanomaterials includes **top-down** and **bottom-up** method.



There here are two approaches for synthesis of nano materials and fabrication of nano structures.

Top down approach refers to slicing or successive cutting of a bulk material to get nano sized particle.

Bottom up approach refers to the buildup of a material from the bottom: atom by atom, molecule by molecule or cluster by cluster

Scanning Electron Microscope, transmission electron microscope, Atomic force microscope are various ways for the detection of nanomaterials high depth.

Spectroscopic methods, X-ray and Neutron diffraction are used for determination of atomic structure and chemical composition of solid or liquid nanomaterials.

Scanning Electron Microscope **SEM** and transmission electron microscope **TEM** are used for determination of atomic **size and shape for** nanomaterials.

SOL-GEL METHOD:

- It is a very popular method used for the preparation of oxide nanomaterials.
- Sol-gel process involves hydrolysis followed by condensation.
- A metal or metalloid employed as a precursor is dispersed in acid or water to form a sol. Gel is obtained from this sol by the removal of water.

  MOR + H_2O ______________ MOH +ROH (hydrolysis)

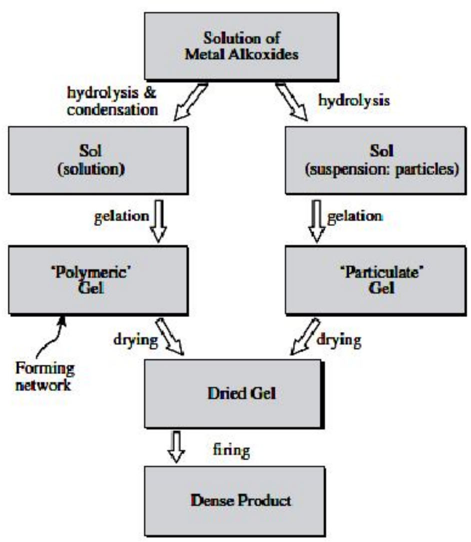
  MOH + ROM__________________ MOM + ROH (condensation)

  The various steps involved are as follows

  1. First the solvated solution of the alkoxide or metal is formed.
  2. Solvation is followed by polycondensation due to the formation of oxide alcohol-bridged network. This leads to gelation and increases the viscosity of the solution dramatically.
  3. Gradually, the gel solidifies and the smaller practices aggregate to form larger particles, a process called coarsening.
  4. This is followed by drying of the gel where water and volatile liquids are removed from the gel network. After this surface bound M-OH groups are removed so that the gel is stabilized against rehydration.

Advantages:

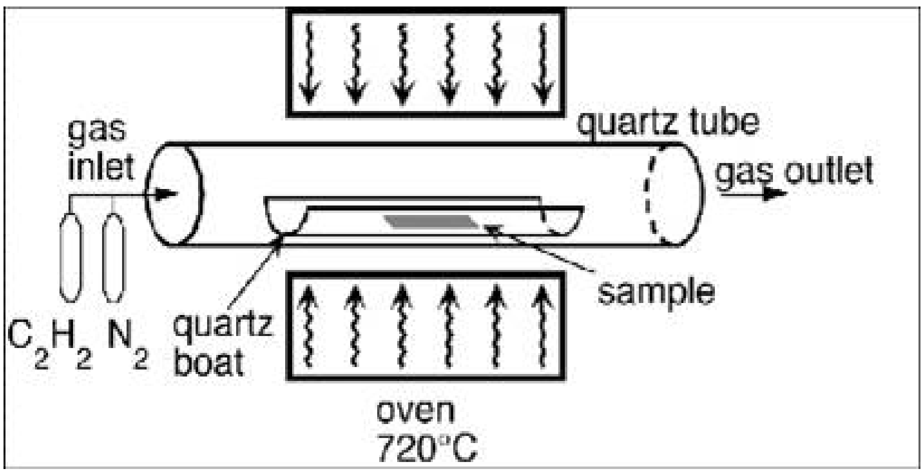
- It can produce thick coating to provide corrosion protection performance.
- It can have low temperature sintering capability, usually 200-600°C.
- It can provide a simple, economic and effective method to produce high quality coatings.
- It can easily shape materials into complex geometries in a gel state.



THIN FILM BY CHEMICAL VAPOUR DEPOSITION METHOD:

- The **Chemical vapor deposition** (CVD) method was developed in 2007 at University of Cincinnati, USA.
- This method is carried out either in the gas phase or on substrate materials.
- It is a chemical process used to produce high quality, high-performance, solid materials.
- During CVD process a substrate was prepared with a layer of metal catalyst nanoparticles (Ni or CO).
- The substrate is heated to 720^{0}C and a mixture of nitrogen and carbon containing acetylene or ethylene or methane was passed.
- The CNT grows at the surface of the catalyst particle where it forms CNT.

CH_4 (g) -------------------- C(s) + $2H_2$(g)



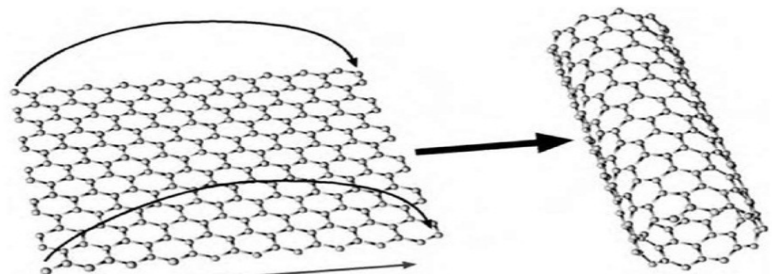
Applications:

- In semiconductor and microelectronic industries.
- In metallurgical coating industries.
- Optical fibers for telecommunications.
- Wear resistant coatings, corrosion resistant coatings, heat-resistant coatings etc.
- Preparation of high temperature materials.

Carbon nano tubes (CNTs):

- CNTs were discovered in 1991 by S.Iijima.
- CNTs are large macromolecules that are unique for their size, shape, and remarkable physical properties.
- CNTs are allotropes of carbon belonging to the fullerene family.
- CNT consists of a sheet of carbon atoms that are sp^2-hybradized and have a hexagonal symmetry.

- CNT is produced by rolling a graphene sheet into a cylindrical shape.



Graphene sheet SWNT

Properties:

- They possess very high tensile strength and stiffness.
- They have unique electronic and mechanical properties.
- They are 100000 times thinner than the human hair.
- They combine rigidly and flexibly and can be hundreds of stronger than steel, but six times lighter.
- They posses high conductivity, chemical specificity and inertness.

TYPES OF CARBON NANOTUBES:

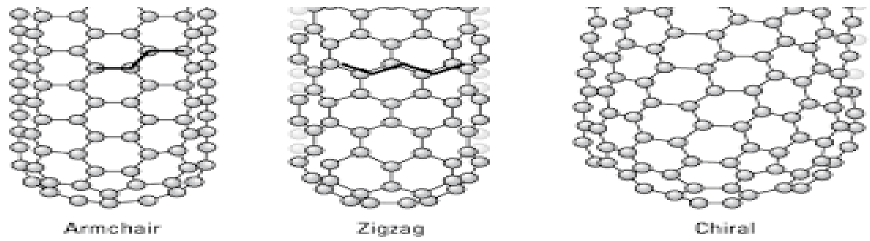
They are two types of CNTs.

(i) Single – walled (one tube) nano tube. (SWNT)

(ii)Multi-walled (several concentric tubes) nano tube. (MWNT)

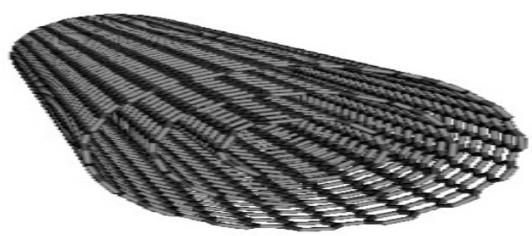
Single – walled nano tube. (SWNT)

- SWNT can be obtained by wrapping a one-atom-thick layer of graphite called graphene into seamless cylinder.
- SWNT exhibit electronic properties.
- SWNTs are three types based on the way the graphene sheet is wrapped.
- Graphene sheet is represented by pair of indices (n,m) called the chiral vector.
    - If m=0, the nano tubes are called Zig-Zag.
    - If n=m, the nano tubes are called armchair.
    - Otherwise, they are called chiral.



MULTI –WALLED NANO TUBES (MWNTs):

- MWNTs consist of multiple rolled layers of graphite.
- The interlayer distance in MWNTs is close to the distance between graphene layers in graphite is 3.3 A^0.
- MWNTs exhibits both metallic and semi conducting properties.
- MWNTs are two models
    - In the Russian doll model, sheets of graphite are arranged in concentric cylinders.e.g-(0 , 8) SWNT within layer (0 ,10)SWNT
    - In the Parchment model, a single sheet of graphite is rolled in around itself, resembling a scroll of a rolled newspaper.



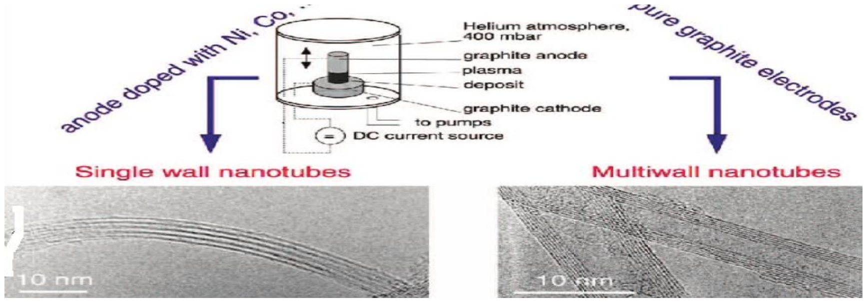
MWNT

PREPARATION OF CARBON NANO TUBES:

ARC DISCHARGE METHOD:-

- This method creates nanotubes through arc-vaporization of two carbon rods placed end to end.
- Separated by 1mm, in an enclosure that is usually filled with inert gas (helium, argon).at low pressure (between 50 and 700 mbar).
- A direct current of 50 to 100 A driven by approximately 20V creates a high temperature discharge between the two electrodes.
- The discharge vaporizes one of the carbon rods and forms a small rod shaped deposit on the other rod.

- The yield is 30% and produces both single and multi-walled nanotubes.



Properties:

- The atomic arrangements of carbon atoms are responsible for the unique electrical, thermal, and mechanical properties of CNTs. These properties are discussed below.

(i) Mechanical properties:

- Carbon nanotubes are the strongest and stiffest materials in terms of tensile strength and elastic modulus respectively.
- This strength results from the covalent sp^2 bonds formed between the individual atoms.

(ii)Electrical properties:

- CNTs exhibit both metallic and semiconducting properties.
- This depends on the symmetry and unique electronic structure of graphene.
- For a given (n, m) nanotube
  - If n=m, the nanotube is metallic.
  - If n-m is multiple of 3, the nanotube is semiconducting.

(iii) Thermal Conductivity:

- CNTs can exhibit superconductivity below 20 K (approximately −253 ºC) due to the strong in-plane C–C bonds of graphene.
- The strong C-C bond provides the exceptional strength and stiffness against axial strains.
- Moreover, the larger interplane and zero in-plane thermal expansion of SWNTs results in high flexibility against non-axial strains.
- Due to their high thermal conductivity and large in-plane expansion, CNTs exhibit exciting prospects in nanoscale molecular electronics, sensing and actuating devices, reinforcing additive fibers in functional composite materials, etc.

Applications of CNTs:

- An SWCNT is strong and stiff with strength hundreds of time stronger than steel and are much lighter. They are widely used in manufacturing reinforced plastics, car and aero plane parts and sports goods.

- MWCNTs have good heat and electrical conductivity and they find use in chemical sensors, conducting paints.
- SWNTs find use in solar panels because of their tendency to absorb UV-Visible and near IR-light.
- Electrically conducting CNT films are used in LCDs, touch screens and photovoltaic devices.
- MWNTs are used in lithium ion batteries.
- In medical field, CNTs are used in implant materials and nanotubes loaded with drugs can be applied directly to the affected area.
- CNTs are used for the treatment of cancer. They absorb light from infrared laser and incinerate the tumor.
- CNTs find use in water purification.
- They are used in stain-resistant textiles.
- Sensors made from nanomaterials are extremely sensitive to the change in environment. some of the sensors are smoke detectors, ice detectors on aircraft wings, automobile engine performance sensors.

Quantum dots:

- Quantum dots are a new innovative perspective on the traditional semi-conductors.
- Quantum dots can be synthesized to be any size, and therefore produce essentially any wavelength of light.
- Quantum dots are semiconductors that are on the nanometer size.
- Quantum dots are the range from 2 to 10 nm in diameter.
  e.g—5to6, emit longer wavelength (orange/red).
  2to3, emit shorter wavelength (blue/green).
- They are made strictly from semiconductor material such as chalcogenides (selenides and sulfides) of metals such as cadmium or zinc (CdSe or ZnS).
- It obeys quantum mechanical principle of quantum confinement.
- Exhibit energy band gap that determines required wavelength of radiation absorption and emission spectrum.
- Requisite absorption and resultant emission wavelength dependent on dot size.

Applications:

- They are used in photolysis reactions and in the manufacture of dye-synthesized solar cells.
- Quantum dots also find their application as biological labels and drug carriers.
- Quantum dots can be useful tool for diagnosis and treatment of cancer.

- In electronic industry, they are used for the preparation of photovoltaic cells and other electro chromic devices.
- In environmental technology. It can be used to remove pollutants from environment (CdS nanocrystal fix atmospheric carbon dioxide).

UNIT-I

Assignment cum Tutorial questions

SECTION-A

Objective Questions.

1. The prefix "nano" comes from [ ]
   a) French word meaning billion b) **Greek word meaning dwarf**
   c) Spanish word meaning particle d) Latin word meaning invisible
2. Who first used the term nanotechnology and when? [ ]
   a) Richard Feynman, 1959 b) **Norio taniguchi, 1974**
   c) Eric Drexler, 1986 d) Sumio Iijima, 1991
3. Nanoscience deals with materials whose size range from [ ]
   a) 1-10 nm b)**10-100nm** c)100-1000nm d) >1000 nm
4. According to the definition by CRN, nanotechnology is... [ ]
   a) mechanical engineering b**) atomic engineering**
   c) Newtonian mechanics d) micro-electronics
5. Nanoscience can be studied with the help of... [ ]
   a**) quantum mechanics** b) Newtonian mechanics
   c) macro-dynamics d) Geophysics
6. Carbon atoms make ____ type of bond with other carbon atoms. [ ]
   a) **covalent** b) ionic c) metallic d) hydrogen
7. The diameter of human hair is ____ nm. [ ]
   a) 50,000 b) 75,000 c) 90,000 d**) 1,00,000**
8. Which of the following statement/s is are true? [ ]
   i. Volume to surface area ratio is very large for nanomaterials.
   ii. The cut-off limit of human eye is 10 -5 m.
   iii. Hardness of a SWNT is about 63 x 10 9 Pa.
   iv. Carbon nanotubes are cylindrical fullerenes.
   a) All four b) (ii) and (iv) c) (i), (ii) and (iv) d) **(ii), (iii) and (iv)**
9. Which ratio decides the efficiency of nanosubstances? [ ]
   a) Weight/volume b) **Surface area/volume**
   c) Volume/weight d) Pressure/volume
10. The size of a quantum dot is ____ nm. [ ]
    a) **5** b) 10 c) 50 d) 100
11. Nanomaterials are used in medicine as. [ ]
    a)Drug carriers b) For diagnosis c) For treatment d)**All of the above**
12. Atomic size and shape for nanomaterials are determined by____ [ ]
    a) SEM b) TEM c) SPF d) **SEM AND TEM**
13. The advantages of sol-gel technique in the synthesis of nanomaterials is [ ]
    a) It is a low temperature process b) The product can be obtain in any form
    c) It is polished to optical quality d) **All the above**
14. Method used in the manufacturing of carbon nanotubes are [ ]

a) sol-gel b) chemical vapor deposition c) laser ablation d) **All of these**

15. The bulk material reduced in three directions is known as [ ]
    a) Quantum wire b) Quantum dots c) Film d) **Quantum particle**.
16. Which one of these does not represent type of a carbon nanotube? [ ]
    a) Arm chair b) Chiral c) Zig-Zag d) **Arch discharge**
17. Carbon tubes are made up of [ ]
    a) Graphite sheet b) **Graphene sheet** c) Honey comb d) Plastic

SECTION-B

Descriptive questions

1. What do you mean by NANO?
2. What are nanomaterials?
3. Metion the applications of nanomaterials.
4. Write any four applications of carbon nanotubes.
5. What is Quantum dots? Write its applications.
6. Explain SOL-GEL synthesis for producing nanomaterials?
7. Define carbon nanotube? What are the types of carbon nanotubes?
8. Explain the following (a) SWNTs (b) MWNTs
9. Discuss about the properties of carbon nanotubes.
10. What are nanomaterials? Explain the types of nanomaterials with example.
11. Describe the method of synthesis of carbon nanotubes by arc discharge method.
12. Explain the chemical vapour deposision process for synthesis of nano tubes with a neat diagram.
13. List the methods for producing carbon nanotubes and explain any one of the method with a neat sketch?
14. What are carbon nanotubes? Explain the properties of carbon nanotubes.
15. Explain mechanical and thermal properties of Nanomaterials.

SECTION-C

Additional questions

1. Explain with help of suitable examples how the properties of nanomaterials differ from those of the same materials in bulk size.
2. Why nano materials exhibit different properties? Explain.
3. What is nanotechnology? How it is useful for society.
4. What is nanotechnology? Explain its advantages with the help of few example materials.

UNIT-2

Liquid crystals, electrochemical and biosensors

Objective:

- To impart knowledge about applications of different liquid crystals in various engineering areas, working principle of OLED, CD, Pen drive.
- To impart knowledge of electrochemical reactions in the sensor and working principle of bio-sensor.

Syllabus:

Liquid crystals -types, properties, applications, working principle of Liquid Crystal Display (LCD) - Working principle of OLED-Working principle of compact disc and pen drive.
Sensors and Bio-Sensors – principle, description of an electro chemical sensor – applications, working principle of glucometer – Applications of bio-sensors.

Outcomes: After learning this unit, students will be able to

1. Understand the applications of different types of liquid crystals, which are use in various engineering fields.
2. Explain the working principle of Liquid crystal display (LCD).
3. Express the working principle of Organic light emitting diode (OLED), and its advantage over the use of liquid crystal display.
4. Understand the working of compact disc, pen drive.
5. Explain the working principle and applications of electro chemical sensor.
6. Understand the working principle of bio-sensor.
7. Express the working of glucometer.

Learning material

Liquid crystals:

The condensed fluid phases which exhibit anisotropic in nature are called liquid crystals. Liquid crystal is a phase between solid and liquid states.

Types of

Liquid crystals:

Liquid crystals can be classified as thermotropic liquid crystals and lyotropic liquid crystals.

(a) Thermotropic liquid crystals:

The class of compounds which exhibits liquid crystalline phases as the temperature change is called thermotropic liquid crystals. The liquid crystalline state of these materials can be observed by lowering the temperature of liquids or raising the temperature of solids. Thermotropic liquid crystals are three types.

(i)Nematic liquid crystals:

- Nematic term derived from Greek word “nema” which means “thread”
- All the molecules are oriented along the axis and appear like threads.
- The molecules move either side ways or up and down.
- These liquid crystals are readily aligned in the same direction in the presence of electric and magnetic fields.
- As the temperature increase, the nematic crystals are change into liquids.

  Applications:

  Nematic liquids are used in alphanumeric liquid-crystal displays (LCD s),digital wristwatches and many consumer electronic devices.

(ii) Cholesteryl liquid crystals:

- These liquid crystal molecules are derivatives of cholesterol.
- These types of crystals are parallel to each other but arranged in layers.
- The molecules in successive layers are twisted with respect to the layers above and below to form helical structure.
- These are form non-super imposable mirror images and can rotate the plane polarized light to the right or left. Hence, they are also termed as chiral liquid crystals.
- These crystals have the ability to reflect light of wavelength equal to their pitch length. Hence a colour will be reflect when the pitch is equal to corresponding wavelength.

Applications:

These are used in thermometers, to identify the temperature change by change in colour.

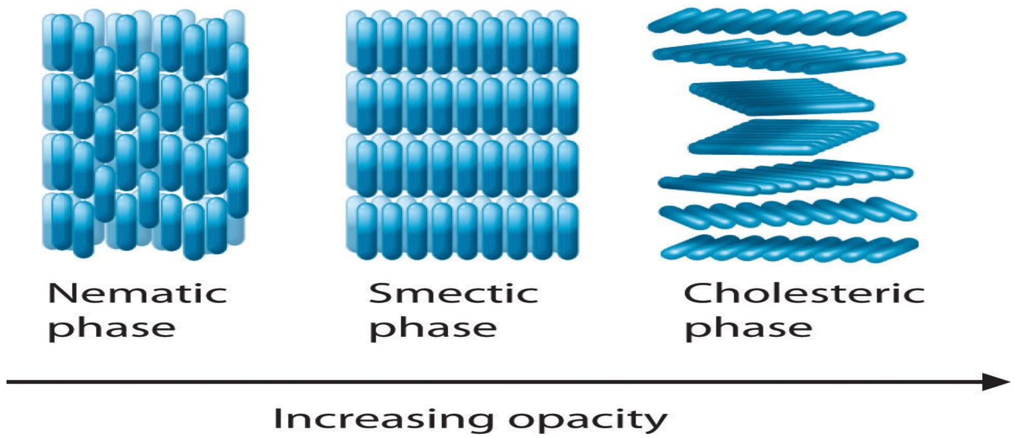
(iii) Smectic liquid crystals:

- The molecules in smectic crystals are oriented parallel to each other, but in layers.
- The molecules are rigid in these layers and cannot move with each other.

- Smectic liquid crystals exhibit long range orientational order and have high viscosity.

Applications:

These are used in making fast moving switching displays.



(b) Lyotropic liquid crystals:

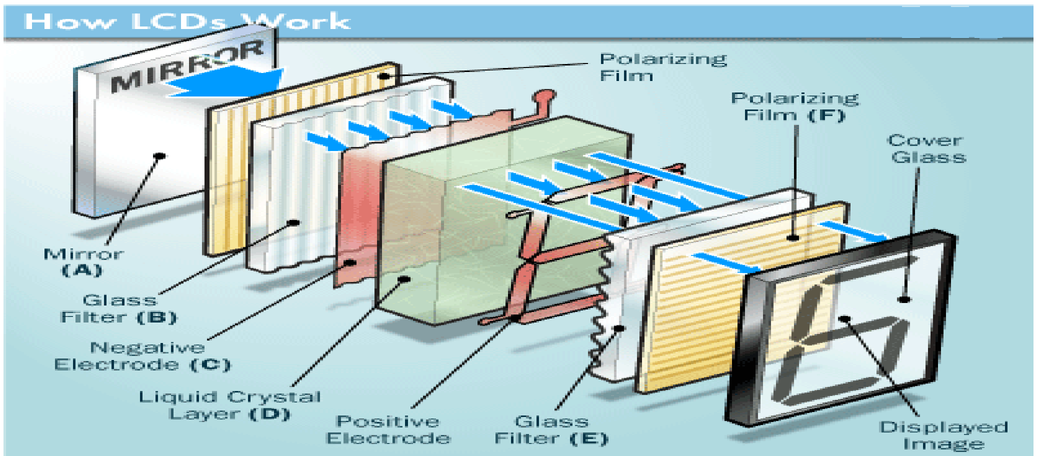
- The compounds which exhibit liquid crystalline behavior when mixed with solvent and with change of concentration in solution are called lyotropic liquid crystals.
- These molecules have both hydrophilic and hydrophobic ends in the molecules.
- The hydrophilic end is attracted towards water, whereas hydrophobic end is water repellant
- At low concentrations these molecules are randomly oriented but as concentration increases, these molecules are arranging themselves. The hydrophobic end in one direction, whereas the hydrophilic end in other direction.

Applications of liquid crystals:

1. Liquid crystals are used in making wrist watches, pocket calculators, flat screen laptops, LCDs.
2. Cholesteric liquid crystals are highly sensitive to change in temperature, so in the electronic industry they use to find faults in circuits, batteries.
3. In medical field, they are used to detect tumors, infections and to locate arteries and veins as these are warmer than surrounding tissues.
4. Colour changing ability of cholesteric crystals with temperature will use in making the sensors for detecting ultraviolet, infrared, microwave radiations.
5. Liquid crystals are use in making electronic paper.
6. Nematic liquid crystals have been used to identify structure of compounds using NMR spectroscopy.
7. These are used as solvents in chromatographic techniques for separation of mixtures.

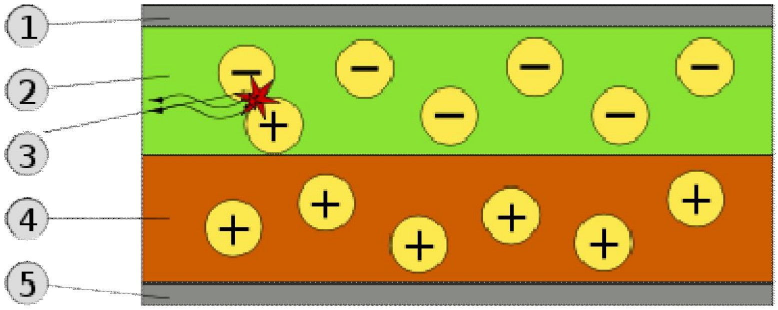
8. Low molecular mass liquid crystals are used for making erasable optical discs, full colour electronic slides for computer aided drawing (CAD) and light modulators for colour electronic imaging.
9. Lyotropic liquid crystals are used in making common soaps.
10. Lyotropic liquid crystals are coated on drugs to prevent them from being destroyed in the digestive tract.

Working principle of liquid crystal display (LCD):



The liquid crystal material is made up of molecules having elongated and rigid structure. These are arranged in spiral structure. In the absence of electric field the polarized light passing through crystals.
Light entering through the first layer is polarized vertically. When this light passes through the liquid crystal, its plane of polarization is rotated by 90° to the horizontal. Thus, this light now is able to pass through the rear horizontal polarizer and then from reflector. Now, the light reflected and return through the two polarizer and crystal.
But in the presence of electric field, all the liquid crystal molecules are line up in the same direction and they have no polarizing effect. So, the light does not pass through the rear polarizer. Then light is absorbed by crystals and form a dark spot on display.

Working principle of OLED:
A typical OLED is composed of an emissive layer, conductive layer, substrate, anode and cathode terminals. These layers are made of organic molecules that conduct electricity. The layers have conductivity levels ranging from insulators to conductors, so OLEDs are considered organic semiconductors.



Schematic of a 2-layer OLED: 1. Cathode (−), 2. Emissive Layer, 3. Emission of radiation, 4.Conductive Layer, 5. Anode (+)

A voltage is applied across the OLED such that the anode is positive terminal and cathode is negative terminal. This causes a current of electrons to flow through the device from cathode to anode. Thus, the cathode gives electrons to the emissive layer and the anode withdraws electrons from the conductive layer.
Soon, the emissive layer becomes negatively charged, while the conductive layer becomes rich in positively charged holes. Electrostatic forces bring the electrons and the holes towards each other and they recombine. This happens closer to the emissive layer, because in organic semiconductors holes are more mobile than electrons. The recombination causes a drop in the energy levels of electrons, accompanied by an emission of radiation whose frequency is in the visible region. That is why this layer is called emissive.
The device does not work when the anode is put at a negative potential with respect to the cathode. In this condition, holes move to the anode and electrons to the cathode, so they are moving away from each other and do not recombine.
Indium tin oxide is commonly used as the anode material. It is transparent to visible light and has a high work function which promotes injection of holes into the polymer layer. Metals such as aluminum and calcium are often used for the cathode as they have low work functions which promote injection of electrons into the polymer layer.

OLEDs offer many advantages over LCDs:

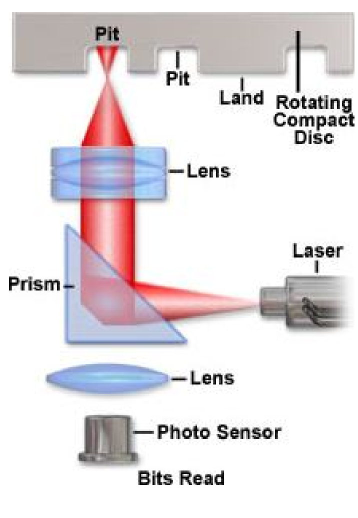
- The plastic, organic layers of OLEDs are thinner, lighter and more flexible than the crystalline layers in LCD.
- OLEDs are brighter than LCDs. Because the organic layers of an OLED are much thinner than the corresponding crystal layers of the LCDs. LCDs require glass for support, and glass absorbs some light. OLEDs do not require glass.
- LCDs require backlight to make the images that you sees, while OLEDs generate light themselves and do not require backlighting, they consume much less power than LCDs (most of the LCD power goes to the

backlighting). This is especially important for battery-operated devices such as cell phones.

- OLEDs are plastic materials; they can be made into large, thin sheets. It is not possible in liquid crystal displays.
- OLEDs have large fields of view, about 170 degrees. But LCDs have an inherent viewing obstacle from certain angles.

Working principle of Compact disc:

The compact disc consists of a clean polycarbonate plastic, during manufacturing this plastic impressed, so microscopic bumps to arrange as single, continuous, extremely long spiral tracks of data. After that a thin aluminum layer is sprayed over it as a single, continuous layer. Then a thin acrylic layer is sprayed over to protect it.
When a high intensity laser beam is focused on aluminum, it forms a tiny pit on it. For reading the data laser beam of less intensity is employed on the pit. Then the reflected laser is sensed by photodiode to read data.
A pit spreads the light so the photodiode receives little reflected light. But the surface without pit reflects more light to the photo diode. Thus the change in reflected light is sensed and converted into electrical signals for data reading.



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Working principle of pen drive:

A pen drive has a male connector at one end, and the rest of the body is a plastic casing that contains a small circuit board. The circuit board contains some power circuitry and three integrated circuits. One of that interfaces to usb connector, other one contains the flash memory and another one that serves as driver for the flash memory. It plugs into any usb port on a computer and is used like an external hard drive.

Sensors:

A sensor is a device that converts a physical phenomenon into an electrical signal. These are used to measure various physical properties such as temperature, force, pressure, flow, position, light intensity.

A good sensor obeys the following rules:

- ❖ It is sensitive to the measured property.
- ❖ It should not encounter with other property.
- ❖ It does not influence the measured property.

Electrochemical sensors:

Electrochemical sensors are used for detection of gasses and metal ions such as Cu^{+2}, Pb^{+2}, Zn^{+2} at sub part per billion level.

Working principle:

Electrochemical sensors are used to detect oxygen and toxic gases. Each sensor is designed to be specific to the gas. These are fuel cells composed of noble metal electrodes in an electrolyte. The electrolyte is aqueous solution of strong inorganic acids.

In normal conditions, oxygen diffuses into the cell and absorbs on both electrodes equally. So a stable potential between the two electrodes is generated, which means no current flows.

The cell chemical process at this point is

$$O_2 + 4H^+ + 4e \longrightarrow 2H_2O$$

When a chemically reactive gas passes through the cell, it is either accepts oxygen or releases oxygen, depending upon the nature of gas. There by the resulting potential difference between the two electrodes causes a current to flow.

Ex: When carbon monoxide gas diffuses then it undergoes oxidation by accepts oxygen and produce potential which will be measure.

The cell chemical process is

At anode: $2\,CO + 2\,H_2O \longrightarrow 2\,CO_2 + 4\,H^+ + 4\,e^-$

At cathode: $O_2 + 4\,H^+ + 4\,e^- \longrightarrow 2\,H_2O$.

Cell reaction: $2\,CO + O_2 \longrightarrow 2\,CO_2$

Applications:

- ➢ To monitor waste stream discharges.
- ➢ To monitor pollutants in the environment.
- ➢ To monitor corrosion process.
- ➢ To monitor blood samples and other body fluids for their ionic chemical concentrations.
- ➢ To monitor levels of ingredients in oils and lubricants.

- ➢ For checking the ionic concentrations of pesticides, fertilizers, pharmaceuticals.

Biosensor:

A biosensor is an analytical device, used for the detection of analyte that combines a biological component with a physiochemical detector.

General Features of Biosensors:

A biosensor has two distinct components
1. Biological component—enzyme, cell etc.
2. Physical component—transducer, amplifier etc.

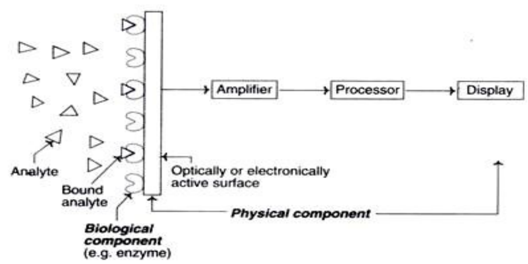


Fig. 21.13 : A diagrammatic representation of a biosensor.

Principle of a Biosensor:

- An analytical tool consisting of an immobilized biological material in contact with a suitable transducer, which can convert a biochemical signal, into an electrical signal.
- Biosensors are operated based on the principle of signal transduction.These components include a biological material, a biotransducer and an electronic system composed of a display, processor and amplifier.
- The biological material,is allowed to interact with a specific analyte.
- The transducer measures this interaction and outputs a signal.
- The intensity of the signal output is proportional to the concentration of the analyte.
- The signal is then amplified and processed by the electronic system.

Characteristics of biosensors:

- ❖ Bio sensors should have good sensitivity. Such that it responses per unit change in analyte concentration.
- ❖ The sensor responds to the target analyte only.
- ❖ The time required for the sensor to indicate the change in analyte concentration is called response time. The good sensor should have low response time.
- ❖ The life time of sensor should be high.

❖ It should measure the lowest concentration of analyte.

Working principle of glucose meter:

The testing device consists of a small, palm-sized, battery powered meter about 5 cm x 9 cm and 1.5 cm thick, with a display screen about 3 cm x 4 cm. The test strips are inserted into a small opening on the top or bottom edge. (The shape of the strip is specially designed so that it cannot be inserted incorrectly.) The electrochemistry of the strip is the key to the operation of the glucose sensor.

The ingredients of a typical test strip are as follows:
29% w/w glucose oxidase (from Aspergillus niger, a fungus),
32%w/w potassium ferricyanide
39% w/w nonreactive ingredients
On each strip, there are about 10 layers, including a stiff plastic base plate. There is a layer containing two electrodes (silver or other similar metal). There also is a layer of the immobilized enzyme, glucose oxidase, and another layer containing microcrystalline potassium ferricyanide, [K3Fe(CN)6]. These layers are suitably separated to allow a small amount of blood to enter.When the end of a strip is touched to a droplet of blood (usually on a fingertip), the blood flows in by capillary action. A “beep” sounds, signalling that testing has begun. In some models, a digital display on the screen “counts down” the seconds till the concentration of glucose is displayed. In the US and Canada, the blood glucose concentration is reported in milligrams per deciliter (mg/dL). However, in Europe the standard is millimoles per liter(mmol/L).

Chemical reaction of the glucose sensor:

The glucose in the blood sample reacts with the glucose oxidase to form gluconic acid, which then reacts with ferricyanide to form ferrocyanide. The electrode oxidizes the ferrocyanide, and this generates a current directly proportional to the glucose concentration.

$$\beta\text{-D-glucose} + O_2 \xrightarrow[\text{phosphate buffer}]{\text{Glucose oxidase, pH=7.3}} \text{gluconic acid} + H_2O_2$$

Applications of bio sensors:

- ❖ Bio sensors are used in the detention of pathogens.
- ❖ It is used to determine the levels of toxic substances.
- ❖ For detection of pesticides and river water contaminants.
- ❖ To detect air borne bacteria in bioterrorist activities.
- ❖ These are used in the analytical measurement of folic acid, biotin, vitamin B.
- ❖ To determine antibiotics residues in meat.
- ❖ To determine the biological activities of new compounds.
- ❖ To determine the amount of organo phosphate in body.
- ❖ Biosensors are used to recognize the DNA sequence.

UNIT-II

Assignment cum Tutorial questions

SECTION-A

Objective Questions.

1. Liquid crystals used in measuring temperature are [ ]
   a) nematic b) smectic c) lyotropic d) cholestric
2. The full form of LCD is [ ]
   a) Liquid Crystal Display
   b) Liquid Crystalline Display
   c) Logical Crystal Display
   d) Logical Crystalline Display
3. Liquid crystal which possess chiral center and form helix are [ ]
   a) cholestric b) nematic c) smectic d) none of the above
4. Certain mesophases with mechanical properties similar to soaps are called
   a) smectic b) lyotropic c) nematic d) thermogrophic [ ]
5. The molecules in the liquid crystals are less ordered.
   a) smectic b) lyotropic c) nematic d) thermogrophic [ ]
6. Clark cell is a sensor used for measurement of which gas in body fluids.
   a) Oxygen b) Chlorine c) HCl d) CO_2 [ ]
7. Among the following which one is converts one form of energy into other form?
   a) Sensor b) Biosensor c) Transducer d) None [ ]
8. The class of compounds which exhibit liquid crystalline phases as temperature is changed are called________________ liquid crystals.
9. The CD disc is made up of a resin, such as___________________
10. The abbreviation of USB is________________
11. The enzyme used in glucose meter is_____________________
12. Mention the examples of organic conducting polymers.

SECTION-B

Descriptive questions

1. What are liquid crystals? Distinguish between thermotropic and lyotropic liquid crystals with examples.
2. Explain the working of liquid crystals in display systems.
3. Write the applications of liquid crystals.
4. How are liquid crystals classified? Give an example in each case.
5. What are smectic liquid crystals? How are they classified?
6. Explain the working principle of pen drive.
7. Give a short note on manufacture of CD.

8. Express the working principle of OLED.
9. Explain the working principle of CD.
10. What are sensors and bio-sensors?
11. Write the features of a good sensor.
12. Outline the applications of sensors.
13. What are characteristics of biosensors?
14. Discuss the construction and working of a glucose meter.
15. Give the applications of biosensors.
16. Write a short note on working of electrochemical sensor.
17. Write chemical reactions involve in glucometer.

UNIT-III
POLYMER TECHNOLOGY

Objective:

- To impart knowledge of different types and preparation methods of reinforced plastics.
- To impart knowledge of properties, applications of fibre reinforced plastics.

Syllabus:

Fibre reinforced plastics – Definition of matrix and reinforcement – Glass fibres, Carbon fibres, aramid fibres – preparation methods – hand layup method, matched metal die moulding method – properties – applications. Conducting Polymers – types, properties and applications.Bio-Degradable Polymers – preparation, properties and applications of Dacron and PHBV.

Outcomes: After learning this unit, students will be able to

1. Understand different types of fibre reinforced plastics.
2. Explain the preparation methods of fibre reinforced plastics
3. Express different types, properties and applications of conducting polymers.
4. Understand preparations, properties and applications of bio-degradable polymers with examples.

Learning material

FIBRE REINFORCED PLASTICS:

General Composition:

Fibre [carbon, glass etc…] + Resin [polymer] = fibre reinforced plastics.

- Fibre Reinforced Plastic or FRP is a composite material consisting of reinforcing fibres, thermosetting resins and other materials such as fillers and pigments may also be present.
- Glass fibre is generally used as a reinforcing material and polyester resins are usually used as bending agent.
- The major application of FRP are consumer products such as chairs trays, helmets, pipe ducts, water cooler body, water tanks panelling etc.

FRP provides an unrivalled combination of properties: -

- Light weight.
- High strength-to-weight ratio (kilo-for-kilo it's stronger than steel).
- High levels of stiffness.
- Chemical resistance.
- Good electrical insulating properties.
- Retention of dimensional stability across a wide range of temperatures.

Common Fiber Types:

- Aramid - Extremely sensitive to environmental conditions.
- Glass (Most Widely Used) - Subject to creep under high sustained loading - Subject to degradation in alkaline environment.
- Carbon - Premium Cost.

Definitions:
Composite Material: A combination of two or more materials to form a new material system with enhanced material properties**.**

Or

Composites are materials consist of two or more constituents. The constituents are combined in such a way that they keep their individual physical phases and are not soluble in each other or not to form a new chemical compound.
One constituent is called reinforcing phase and the one in which the reinforcing phase is embedded is called matrix.

Reinforcement + **Matrix** = **Composite**

Matrix:-

- The plastic material used in FRP is called matrix.
- Matrix is a relatively weak plastic that is reinforced by stronger fibres.
- It transfers the forces b/w the fibres and protects the fibre from the environment.
- Generally thermosetting plastics are used as matrix.
- Vinyl esters and epoxy resins are most commonly used matrixes.

Matrix Phase: – Metals (Cu, Al, Ti, Ni...); Polymers (Thermosets, thermoplastics, Elastomers); Ceramics (SiC...).

Reinforcement (Fibre reinforcement):

- Fibre (reinforcement) is the substance that is used to strengthen plastic compounds.
- The properties of FRP are mainly influenced by the choice of fibres.
- There are three main types of fibres carbon, glass & Aramid fibres.
- They have different properties.
- All fibres have generally high stress capacity than the ordinary steel.

Reinforcement Phase: - Fibers (B, C, Glass, Aramids, PE...); Particles, flakes, ribbons ...

Glass fibre reinforced plastics:
Preparation:

- Glass fibre is made up of sand, limestone, folic acid and other minor ingredients.

- The mixture is heated till it melts at about 1260ºC.
- The molten glass is then allowed to flow through fine holes in a platinum plate.
- The glass strands are cooled, gathered & wound.
- The fibres are woven into various forms for use in composites.
- Another glass fibre prepared from aluminium + lime + borosilicate has high insulating properties, low susceptibility to moisture and high mechanical strength.

Properties:

- They have high surface area to weight.
- Glass fibre has good thermal insulation due to the presence of air gaps.
- Glass fibre absorbs moisture.
- Glass fibre undergoes more elongation before it breaks.
- Glass fibre is drawn at moderately low viscosity. If it is too high, fibre will break during drawing. If it is too low, the glass will from droplets.

Uses:

- Bridges
- Airplane wings
- Boat hulls
- Corrosion resistant equipment
- Circuit boards
- Automobile industry

Aramid fibre reinforced plastics [bullet proof plastic]:

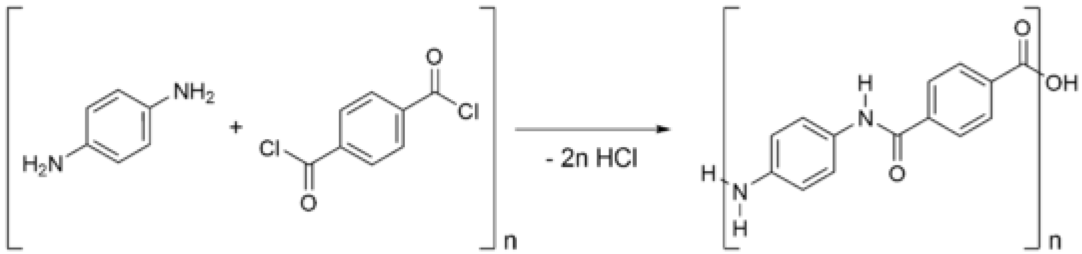
- Aramid is a short form of aromatic polyamide.
- Aramids are a family of nylon, Nomex and Kevlar.
- Kevlar is used to make things like bullet proof vests and puncture resistant bicycle tires.

Kevlar:-

- It is also known as poly (p-phenyleneterephtalamide).

Preparation:-

It is prepared by condensation polymerization of 1,4-diamino benzene and Isophthaloyl Chloride. In Kevlar, the repeating groups between the amide links are benzene rings.



Properties:

- This is five times as strong as steel.
- Usually yellow in appearance.
- Low density.
- High strength.
- Thermal resistance.
- Good impact resistance.
- Good abrasion resistance.
- Good chemical resistance.
- Compressive strength.

Uses:

- These are used in the manufacture of Bullet proof vests
- Boat hulls.
- Aircraft body parts.
- Clutch plates, brake pads.
- Gaskets.
- Adhesives & sealants.

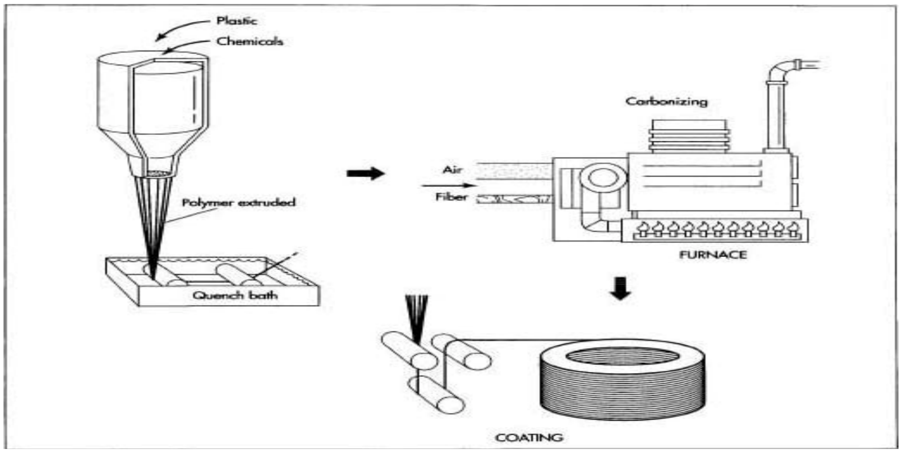
Carbon fibre reinforced plastic :(CFRP)

- CFRP (Carbon Fiber Reinforced Plastic) is a composite material, consisting of various carbon fibers and thermosetting resins.

Preparation:-

- The raw material used to make carbon fiber is called the precursor. About 90% of the carbon fibers produced are made from polyacrylonitrile. The remaining 10% are made from rayon or petroleum pitch.
- The process for making carbon fibers is part chemical and part mechanical. The precursor is drawn into long strands or fibers and then heated to a very high temperature with-out allowing it to come in contact with oxygen. Without oxygen, the fiber cannot burn. Instead, the high

temperature causes the atoms in the fiber to vibrate violently until most of the non-carbon atoms are expelled. This process is called carbonization and leaves fiber composed of long, tightly inter-locked chains of carbon atoms with only a few non-carbon atoms remaining.



Properties:

- High Strength.
- Rigidity.
- High elastic modulus.
- Corrosion resistance.
- Electrical Conductivity.
- Fatigue Resistance.
- Good tensile strength but Brittle.
- Fire Resistance/Not flammable.
- High Thermal Conductivity in some forms
- Low coefficient of thermal expansion.
- Non poisonous.
- Biologically inert.
- X-Ray Permeable.
- Self Lubricating.
- Relatively Expensive
- Requires specialized experience and equipment to use.

Uses:

Airspace and aircraft industries¬ Automotive body parts¬ Mobile cases¬ Musical instruments¬ Badminton racket¬ Golf stick¬ construction industry¬ Wind mill and turbine blades¬ Helmets.

Preparation methods:
Hand layup method:

- Hand lay-up is the simplest and oldest open molding method of the composite fabrication processes.

The processing steps

- First of all, a release gel is sprayed on the mold surface to avoid the sticking of polymer to the surface.
- Thin plastic sheets are used at the top and bottom of the mold plate to get good surface finish of the product.
- The thermosetting polymer in liquid form is mixed thoroughly in suitable proportion with a prescribed hardener (curing agent) and poured onto the surface of mat already placed in the mold. The polymer is uniformly spread with the help of brush.
- Second layer of mat is then placed on the polymer surface and a roller is moved with a mild pressure on the mat-polymer layer to remove any air trapped as well as the excess polymer present.
- The process is repeated for each layer of polymer and mat, till the required layers are stacked.
- After curing either at room temperature or at some specific temperature, mold is opened and the developed composite part is taken out and further processed.
- The time of curing depends on type of polymer used for composite processing.
- This method is mainly suitable for thermosetting polymer based composites.

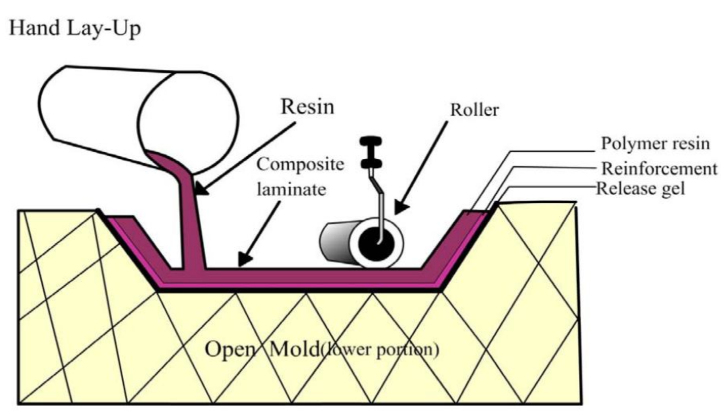
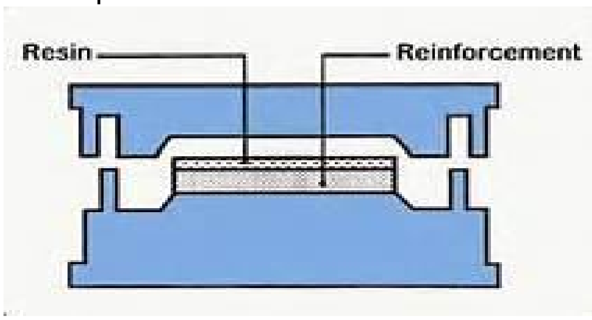


Figure 1 Hand lay-up method.
Figure 1 Hand lay-up method.

Applications: Hand lay-up method finds application in many areas like aircraft components, automotive parts, boat hulls, diase board, deck etc.

Matched metal die moulding method:

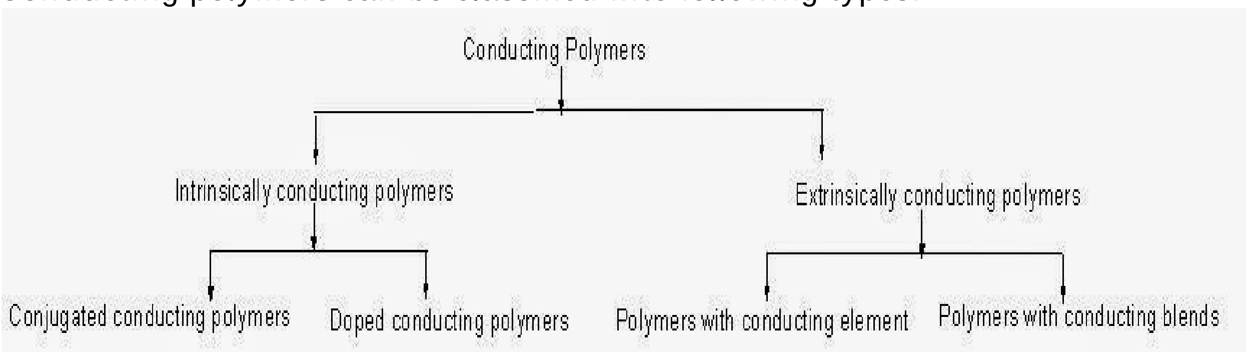
- This is most efficient and economical method for mass production of high-strength parts.
- Parts are press moulded in matched male and female moulds at pressure of 200-300 psi and temperature of 235 to 260^oF.



Applications:

Matched metal die moulding method finds application in many areas like door handles, locks, the outer casing or housing for motors, pumps, etc., wheels of many cars. Casting is also heavily used in the toy industry to make parts, e.g. toy cars, planes, and so on.

Conducting polymers:-The polymers which can conduct electricity are called conducting polymers.
Conducting polymers can be classified into following types:



(i)**Intrinsically conducting polymers**: The conductance of these polymers is due to the extensive conjugation in their backbone.
They are further of two types
(a)**Conjugated π-electron conducting polymers**: The conductivity of these polymers is due to the presence of conjugated π-electrons .The conjugated π-

electrons are delocalized. In an electric field, the π-electrons get excited and are transported through the solid polymeric material.

Ex:-

Poly acetylene

(b) **Doped conducting polymers**: the polymers are doped by adding either electron donors or electron acceptors on the polymeric backbone.

Doping can be of two types

(i)**P-type doping**: when the polymer is treated with a Lewis acid, its oxidation takes place and holes (positive charges) are created on the polymer backbone.

Commonly used p-dopants are I_2, $FeCl_3$, Br_2, AsF_5, etc.

$2(C_2H_2)_n$ + $3I_2$ -------------------------- $2[(C_2H_2)_n^+ I_3^-]$

(ii**) n-type doping:** when the polymer is treated with Lewis base, reduction takes place and negative charges are added on the polymeric chain.

Some common n-type dopants are Li, Na, naphthylamine, etc.

-CH=CH-CH=CH- + $C_{10}H_7NH_2$ --------------- -CH=CH-CH=CH- + $C_{10}H_8$
(Naphthylamine)

Extrinsically conducting polymers:

The conductivity of these polymers is due to presence of externally added ingredients.

They are of two types

(i)Conductive element-filled polymers: when the polymer is filled with conducting elements like carbon black, metallic fibres, metal oxides, their conductivity increases.

(ii)Blended conducting polymers: Conducting polymers are added to conventional polymers. The blended polymers have better physical, chemical and mechanical properties.

Applications of conducting polymers:

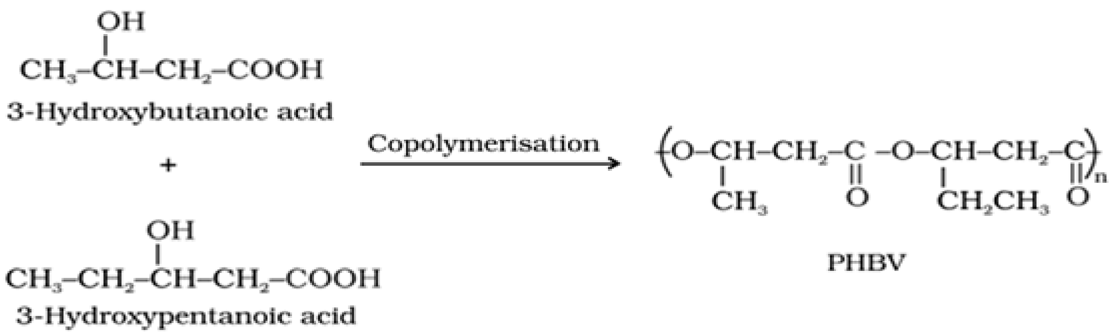
- Conducting polymers find use in electronics, solar cells, displays, microchips.
- In rechargeable light weight batteries.
- Used in photovoltaic devices
- In telecommunication systems.
- Electronic conducting polyaniline is used for producing smart windows.polyaniline shows different colors in different oxidation states.
- They are used in organic light-emitting diodes (OLED's).
- In electronic devices such as transistors and diodes.

Bio-Degradable polymers:
The polymers degrade quickly in living systems by enzymatic chemical reaction like oxidation (or) hydrolysis called Bio-degradable polymers.

(OR)

Biodegradation is the degradation of a material by environmental factors such as sunlight, temperature changes or by the action of microbes (bacteria, fungi, etc).

(a) Poly β-hydroxy butyrate-co- β-hydroxy valerate (PHBV):
It is co-polymer of 3-hydroxy butanoic acid and 3-hydroxy pentanoic acid.



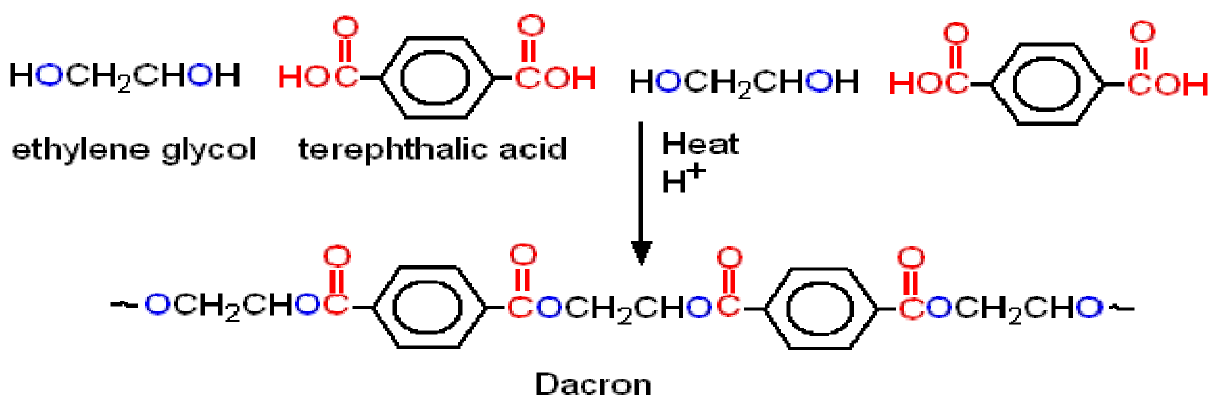
Properties:

- The excess amount of 3-hydroxy butanoic acid makes the copolymer tougher.
- While extra proportions of 3-hydroxy pentanoic acid makes the copolymer more flexible.

Applications:

- This polymer is used in medicine for making capsules.
- It is also used in specialty packing and in orthopedic devices.

(b) Dacron (polyester):
IT is obtained by polycondensation between terphthalic and ethylene glycol as follows.



Properties:

- Good resistance to water.
- Attacked by bases like NaOH.

- It has good tensile strength.
- It has good mechanical property like high moulding.

Applications:

- Used for making of safety belts, magnetic recording tapes.
- Used for making of PET bottles like cool drinks, fruit juices, beer etc...

UNIT III
Assignment Cum Tutorial

Section - A

Objective Questions

1. Kevlar is commercial name for __________ [ ]
   (a) Glass fibers (b) Carbon fibers (c) Aramid fibers (d) Cermets
2. Which of the following is an application of glass-fiber reinforced composites? [ ]

   (a) Adhesive (b) Conveyor belts
   (c) Design of ships (d) Automotives
3. The main raw materials for producing carbon fiber are [ ]
   (a) Pitch (b) Polyacrylonitrile (c) polyethylene (d) Rayon
4. Which of the following is not required for the biodegradation process? [ ]
   (a) Micro-organism (b) Environment conditions
   (c) **Adhesives** (d) Substrate
5. When fibers are used as dispersed phase for the reinforcement of matrices, the resultant composites are known as [ ]
   (a) Glass-fiber reinforced (b) Carbon-fiber reinforced
   (c) Wood-fiber reinforced (d) Unidirectional-fiber reinforced
6. Which of the following is not a property of matrix materials which are modified by adding particulate fillers? [ ]
   (a) Improved performance at elevated temperature
   (b) Decrease in surface hardness
   (c) Modification in electrical conductivity
   (d) Improved abrasion resistance
7. Which of the following is used as reinforcement in advanced polymer matrix composite? [ ]
   (a) Glass-fiber reinforced (b) Carbon-fiber reinforced
   (c) Wood-fiber reinforced (d) Unidirectional-fiber reinforced
8. Which of the following is not an advantage of composites? [ ]
   (a) Easy to manufacture and durable
   (b) Excellent thermal, mechanical and chemical properties
   (c) Heavy-weight and non-versatile
   (d) Economical and tailor mad
9. Terylene or terene or Dacron is a polymer of [ ]
   (a) Hexamethylene diamine and adipic acid (b) Ethylene glycol and terephthalic acid
   (c) Ethylene glycol and phthalic acid (d) phthalic acid and glycerol
10. The first known conducting polymer is [ ]

(a) Polyacetylene doped with iodine (c) Polyaniline doped with HCl
(b) Polypyrrole doped with BF^{-}_{4} (d) Polythiophene doped with ClO^{-}_{4}

11. Which the following polymers are used for organic light emitting diodes. [ ]
(a) Poly carbonate (b) poly phenylene vinylene(PPV)
(c) Poly acetylene (d) poly (p-phenyleneterepthalamide).

12. Bio degradable polymers are use in [ ]
(a) Orthopaedic fixation devices (b) Controlled drug delivery
(c) Manufacture of plastic bags (d) All the above.

13. Polymers are degrade by [ ]
(a) Heat (b) Radiation (c) Oxidation (d) All the above

14. Which of the following is not an example of natural biodegradable polymer? [ ]
(a) Collagen (b) Polyvinyl alcohol (c) Lignin (d) Natural rubber

SECTION-B

Descriptive questions

1. Define reinforcement and matrix.
2. What is bio-degradable polymer?
3. What are different types of conducting polymers?
4. Explain the following methods.
   (a) Hand lay-up method
   (b) Matched-metal die moulding method.
5. How the PHBV prepare from its monomers. Mention the applications of PHBV.
6. Explain preparation and properties of Dacron.
7. What are conducting polymers? Give the applications of conducting polymers.
8. Write a short note on aramid fibers.
9. What is carbon fibre reinforced composite? Discuss their properties and applications.
10. What are composite materials? Discuss about glass fibre composite.

UNIT - IV

Non-Elemental Semiconductors & Super Conductivity

Objective:

- To impart knowledge of different types, properties and applications of semiconductors used in engineering.
- To impart knowledge of properties, applications of superconductors.

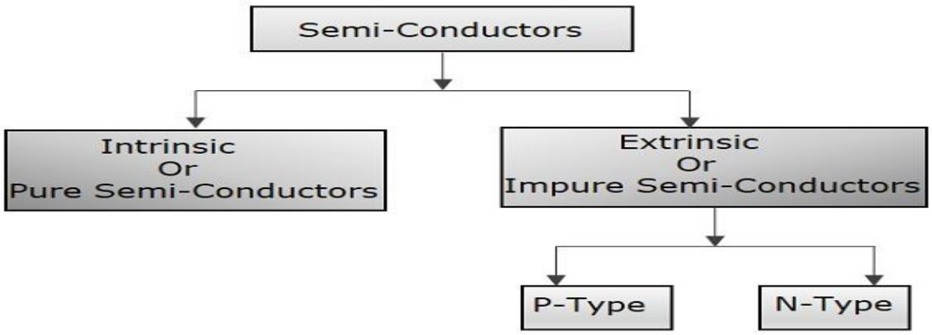
Syllabus:
Non-Elemental Semiconductors & Super Conductivity: Stoichiometric semiconductors, Non- Stoichiometric semiconductors, controlled valency semi conductors, preparation of ultrapure Si and Ge. Introduction of super conductors – types of super conductors, preparation of 1-2- 3 super conducting pellet – classes of super conductors, properties and applications of super conductors.

Outcomes: After learning this unit, students will be able to

1. Understand different types of semiconductors.
2. Explain the preparation methods of ultrapure semiconductors.
3. Express different types, properties and applications of superconductors.

Learning material

Introduction to semiconductor:
Semiconductors: A semiconductor material is one whose electrical properties lie in between those of insulators and good conductors.
In terms of energy bands, semiconductors can be defined as those materials which have almost an empty conduction band and almost filled valence band with a very narrow energy gap (of the order of 1 eV) separating the two.
Examples are: germanium and silicon.
Types of Semiconductors: Semiconductor may be classified as under:



a. **Intrinsic Semiconductors:** An intrinsic semiconductor is one which is made of the semiconductor material in its extremely pure form.
Examples are: pure germanium and silicon

b. **Extrinsic Semiconductors:** Those intrinsic semiconductors to which some suitable impurity or doping agent or doping has been added in extremely small amounts are called extrinsic or impurity semiconductors.

Depending on the type of doping material used, extrinsic semiconductors can be sub-divided into two classes: (i) N-type semiconductors and (ii) P-type semiconductors.

Non-Elemental Semiconductors:
Besides Si and Ge, many intermediate and ceramic compounds exhibit semi conductivity.
These compounds may be groups into following.

a) Stoichiometric semi conductors:

- Stoichiometric semi conductors are intermediate compounds having an average four valence electrons per atom and possess crystal structures and band structure similar to those of Si and Ge.
- These intermediates are prepared by the combination of : (i)elements of group III(Ga,In) and group V (P,As,Sb).(ii)elements of group II (Cd,Pb) and group VI (S,Se,Te).
- Example: GaAs is III-V group's combination.
- GaAs compound has a wide energy gap of 1.35 eV and this can be used as a semiconductor with wide temperature range than the elemental semiconductors.
- The energy gap in the stoichiometric semi conductors can be reduced by substituting one of its elements by an element of higher atomic number.
  Example: GaP--------2.24eV, GaAs---------1.35eV.

b) Non- Stoichiometric semiconductors:(Defect semiconductors)

- Many non-stoichiometric semi conductors act as semiconductors.
- Example: metallic oxides and sulphides in non-stoichiometric crystalline structures.

Defect semiconductors are of two types:

(i) Metal ion-deficient semiconductors:

- These Metal ion-deficient non-stoichiometric semi conductors can be represented as $M_{(1-x)}Y$.
- These are act as p-type semiconductors.
- Examples: FeO, Cu_2O, NiO, and FeS.
- When FeO is exposed to heat, non-stoichiometric compounds such as $Fe_{0.90}O$ ($Fe^{2+}_{0.70}Fe^{+3}_{0.20}O^{2-}$).since Fe^{3+} ion is short by one electron wrt to Fe^{+2}, so Fe+3 in FeO crystal lattice as a positive hole. Consequently, under the influence of electric field, the positive hole can move from Fe+3 to Fe+2 ions, thereby producing electrical conductivity.

(ii) Metal ion-excess semiconductors:

- These Metal ion-excess non-stoichiometric semi conductors can be represented as $M_{(1+x)}Y$.
- These are act as n-type semiconductors.
- Examples: ZnO, CdO, Cr_2O_3, Fe_2O_3, PbS, ZnS.
- When ZnO is exposed to reducing atmosphere, non-stoichiometric compounds such as $Zn_{1.1}O$ ($Zn^{+2}_{0.9}Zn^{+}_{0.2}O$) are produced by partial removal of oxygen. In such compound, Zn^{+} ion is rich by one electron wrt Zn^{+2}, so each Zn^{+} ion is capable of donating one electron to the conduction band. Hence, under the influence of electric field, ZnO act as an n-type semiconductor.

Limitations: One problem with defect semiconductor is the difficulty in controlling their conductivity, since it depends both on the temperature and oxygen pressure during preparation.

Example: NiO on oxidation at 1000 ^{o}C in air produces p-type semiconductor.

c) Controlled valency semiconductors:

- The above limitation of defect-semiconductor is overcome by preparing controlled valency semiconductor.
- In order to control the concentration of Ni^{+3} ions in NiO and hence its conductivity,a calculated amount of lithium oxide (Li_2O) is reacted with nickel oxide and oxygen to compounds,$Li_3Ni^{+2}_{1-2x}Ni_x^{3+}O$,which exhibit temperature dependent conductivities.

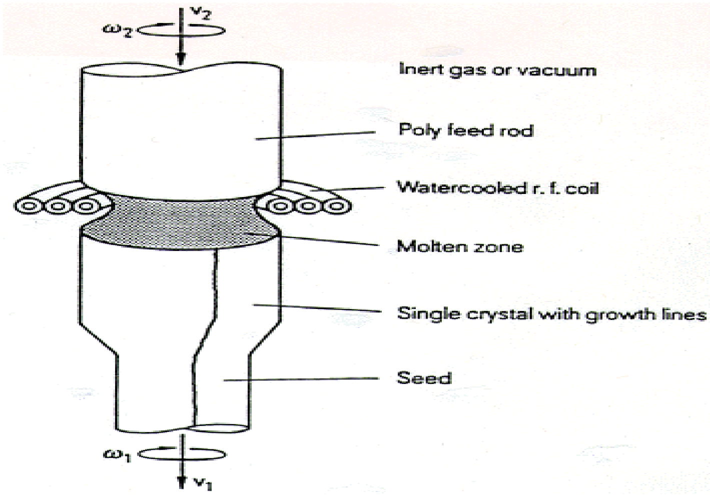
Preparation of ultrapure Si and Ge:

(a)Distillation method:

- This method is based on the separation of materials due to difference in boiling points.
- The starting raw materials are germanium tetrachloride ($GeCl_4$) and trichlorosilane ($SiHCl_3$) for the preparation of pure Ge and Si respectively.
- $GeCl_3$ (b.p.83.1^o C) is taken in a series of distillation stills and layers of HCL is placed over the charger, which remove As (usually present as an impurity).
- Chlorine gas is then passed through the charger, which is heated electrically.
- The vapours passing through the fractionating column finally distils over in receiver, kept in an ice bath.
- Pure $GeCl_4$ is obtained, which is then treated with extra pure water to get GeO_2.which is subsequently reduced to get elemental germanium.
- Similarly, distillated $SiHCl_3$ is employed to get silicon of high purity.

(b)Zone refining method:

- Zone refining is a technique used to purify materials.
- Basic of this is that "impurities are more soluble in the melt than in the solid material".
- A vertical zone refiner is used for the purification of Ge.
- A rod of already purified Ge is clamped vertically and heated to about 1000^{o}C in a reducing atmosphere.
- The heating coil is very slowly moved from top to bottom, the impurities are sweft drawn with molten material. While pure Ge rod solidified at the upper portion.
- When the purification of upper portion of the rod is complete, the bottom portion of the rod is separated.
- By using repeated zone refining, the impurity level can be reduced to 1 atom per 10^{12} atoms of Ge.



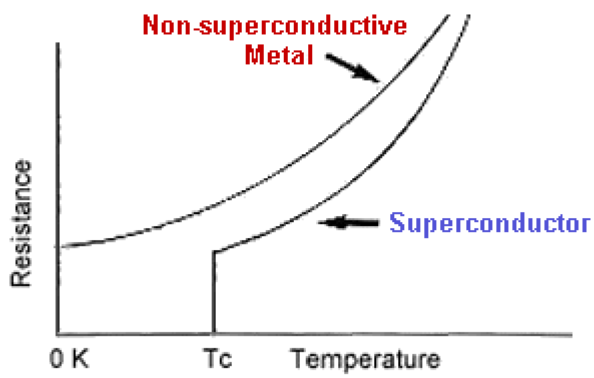
Introduction of super conductors:

Super conductors:

- A superconductor is a material that can conduct electricity or transport electrons from one atom to another with no resistance.

  (or)

  Materials are said to be superconducting, when they offer no resistance to the passage of electricity.
- Materials in superconducting state become diamagnetic and repelled by magnets.
- This phenomenon of superconductivity was first observed by Kammerlingh Onnes in 1913, when they found that mercury became superconducting at around 4 K.



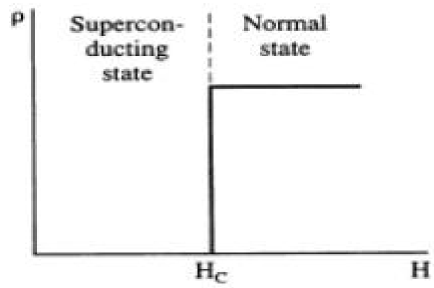
Critical temperature (**T_c**): The temperature at which electrical resistance is zero is called the **critical temperature** (**T_c**).

Transition temperature: The temperature at which a substance starts behaving as superconductor is called **transition temperature.**

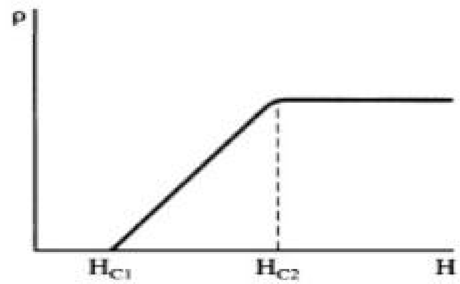
This temperature lies in between 2 to 5K.

The transition temperature of mercury is 4.2K

Types of super conductors:
According to transition period superconductors are classified into following two classes.
Type-1 (soft) superconductors: The superconductors which transit from superconducting state to normal state sharply due to any limiting parameters (especially magnetic field) are known as type-1 or soft superconductors.

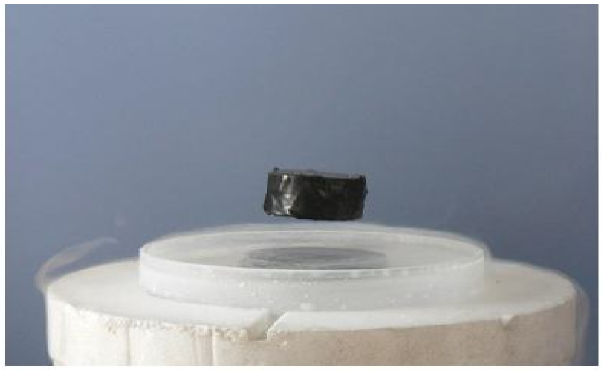


Type-II (hard) superconductors: The superconductors which transit from superconducting state to normal state gradually due to any limiting parameters (especially magnetic field) are known as type-II or hard superconductors.

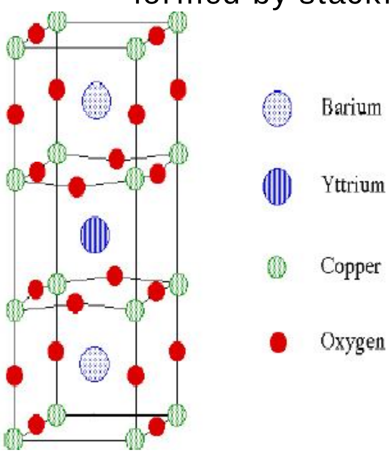


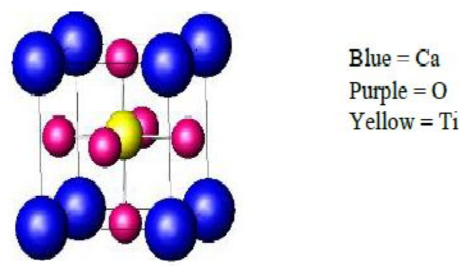
Above figure shows the schematic representation of the resistivity of a hard superconductor when a magnetic field H is applied. The region between H_{C1} and H_{C2} is called the vortex state in which superconducting and normal conducting areas are mixed. Above H_{C2} the solid behaves like a normal conductor.

Synthesis of a High Temperature Superconductor:
- In this laboratory exercise we will synthesize the ceramic YBa2Cu3O7-x, called the 1-2-3 superconductor because of its metal's stoichiometry.
- The importance of this material is that it is a high temperature superconductor of Type II. As such, a pellet of this material, when immersed in liquid Nitrogen, will exhibit the Meisssner effect by levitating a small magnet.



- The unit cell for our 1-2-3 Superconductor is an orthorhombic structure formed by stacking Perovskite (CaTiO3) like structures.





Perovskite Structure

Preparation method:

There are a couple of methods commonly employed for its synthesis. The method we will use involves mixing the oxides of each metal in stoichiometric proportions and heating them until the reaction is complete. The heating stage is critical. We initially heat the mixture to 930^{o}C. During this heating period the basic structure of the Superconductor is established by diffusion of the appropriate ions. The material is then cooled to 500^{o}C where further reaction occurs with Oxygen in the air to provide a net deficit of about x = 0.1 in the final formulation of $YBa_2Cu_3O_7$-x. This process can be represented roughly as:

½ Y_2O_3(s) + 2 BaO_2(s) + 3 CuO(s) ----------------→$YBa_2Cu_3O_7$-x(s)

Once our compound has been synthesized, we will test it for its ability to levitate a small magnet when cooled to liquid Nitrogen temperatures.

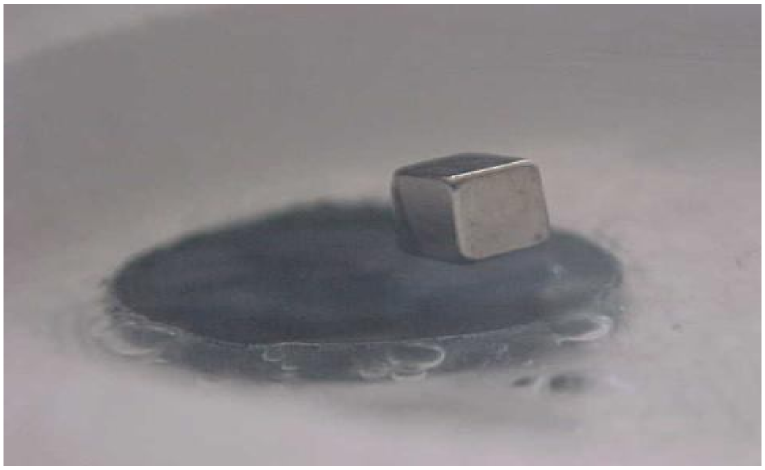
Properties of superconductors:

- They possess greater resistivity then other elements at room temperature.

- On adding impurity to superconducting element, the critical temperature is lowered.
- During transition, neither thermal expansion nor elastic properties change.
- In superconductivity state, all electromagnetic effects disappear.
- Application of sufficient strong magnetic field is applied to superconductors below its critical temperature causes destruction of its superconducting property.
- When a not too strong magnetic field is applied to a superconductor and this is cooled to low temperature below its transition temperature, then the superconductor expels all magnetic flux from its interior. This known as **Meissner effect**.
- In other words, if the magnetic field is applied after the superconductor has been cooled below its critical temperature, then the magnetic flux is excluded from the superconductor.

MEISSNER EFFECT

The property of superconducting materials is the Meissner Effect. It was observed that as a magnet is brought near a superconductor, the magnet encounters a repulsive force. It can be said that the superconductor completely expels the magnetic field and behaves as a perfect diamagnet.



Applications of superconductivity:

- Superconducting magnets capable of generating high fields with low power consumptions are being employed in scientific tests and research equipments.
- They are also used for magnetic resonance imaging (MRI) in the medical field as a diagnostic tool. On the basis of the production of cross – sectional images, any abnormalities in body tissues and organs can be detected. Chemical analysis of body
tissues in also possible by magnetic resonance spectroscopy (MRS).

- Other numerous fields in which superconductivity is used are:
  i. Electrical power transmission through superconducting materials – power loss is extremely low and equipment operates at low voltage levels.
  ii. Magnets for high – energy particle accelerators.
  iii. High-speed switching and signal transmission for computers.
  iv. High-speed magnetically levigated trains wherein the levigation results from magnetic repulsion.
  v. Memory or Storage element on computers.
  vi. For amplifying very small direct current and voltages.
  vii. In magneto-hydrodynamic (MHD) power generators to maintain plasma. These superconducting materials are smaller in size and consume less energy.

UNIT IV
Assignment Cum Tutorial

Section - A

Objective Questions

1. The most commonly used semiconductor is .... [ ]
   (a)Germanium (b) Silicon (c) Carbon (d) Sulphur
2. A semiconductor has generally .... valence electrons. [ ]
   (a) 2 (b) 3 (c) 6 (d) **4**
3. Which of the following is not required for the biodegradation process? [ ]
   (a) Micro-organism (b) Environment conditions
   (c) **Adhesives** (d) Substrate
4. An n-type semiconductor is .... [ ]
   (a)Positively charged (b) **Negatively charged**
   (c)Electrically neutral (d) None of the above
5. In superconductivity, the electrical resistance of material becomes [ ]
   (a) **Zero** (b) Infinite (c) Finite (d) All of the above
6. The temperature at which conductivity of a material becomes infinite is called [ ]
   (a) **Critical temperature** (b) Absolute temperature
   (c) Mean temperature (d) Crystallization temperature
7. The superconducting state is perfectly _____ in nature. [ ]
   (a) **Diamagnetic** (b) Paramagnetic
   (c) Ferromagnetic (d) Ferromagnetic
8. Which of the following are the properties of superconductors? [ ]
   (a) They are diamagnetic in nature (b) They have zero resistivity
   (c) They have infinite conductivity (d) **All the above**
9. A metal deficient ionic compound acts as [ ]
   (a) *n*-type semiconductor (b) ***p*-type semiconductor**
   (c) Intrinsic semiconductor (d) none of these
10. In Type-II superconductors, the transition from superconducting to normal state by the application of magnetic field is. [ ]
    (a) Sharp (b) **Not Sharp** (c) Erratic (d) None
11. In Type-I superconductors, the transition from superconducting to normal state by the application of magnetic field is. [ ]
    (a) **Sharp** (b) Not Sharp (c) Erratic (d) None
12. The transition temperature o mercury is. [ ]
    (a**) 4.2K** (b)7.5K (c) 12K (d) 20K
13. Match the following: [ ]

Column-II	Column-II
A) Metal ion-deficient semiconductors	i) Zone refining method
B) Metal ion-excess semiconductors	ii) p-type semiconductors

C) ultrapure Si	iii) n-type semiconductors semiconductor
	iv) Distillation

(a) A-i,B-iii,C-iv (b)A-ii,B-i,C-iii (c) A-iv,B-ii,C-i (d) **A-ii ,B-iii ,C-i**

14. Superconductivity was first observed by [ ]

(a**)** Ohm (b) Ampere (c) **H.K. Onnes** (d) Schrieffer

SECTION-B

Descriptive questions

1) What are defect semiconductors?
2) What is Critical temperature (T_c)?
3) What is Meissner Effect?
4) What is superconductor?
5) Name one superconducting materials.
6) Mension any four applications of superconductors.
7) What are controlled valency semi conductors?
8) Write short note on stiochiometric semiconductors.
9) What are Non-stoichiometric semiconductors? Explain the following
   (a) Metal ion-deficient semiconductors
   (b) Metal ion-excess semiconductors
10) What are superconductors? Explain types of superconductors.
11) What are superconductors? Discuss their properties and uses.
12) Describe the preparation of semiconductor grade germanium from $GeCl_4$.
13) What are high temperature superconductors? Give the preparation of 1:2:3 superconductor.

UNIT-V

Energy Storage Devices

Objective:

- To impart the knowledge in chemistry and applications of secondary batteries and fuel cells used in engineering.
- To impart knowledge in different types of solar cells and harnessing of solar energy.

Syllabus:

Energy Storage Devices:

Secondary cells. Construction, electro chemical reactions and applications of secondary cells-, Lithium ion battery, Pb-acid storage battery, maintenance free lead acid battery. Construction, electro chemical reactions and applications of Fuel cells – H_2-O_2 fuel cell, Methanol-oxygen fuel cell. Solar energy – Photo Voltaic Cells, Photosensitizing diode, Solar Reflector (parabolic trough, solar dish, solar tower).

Outcomes: After learning this unit, students will be able to

1. understand different types of secondary cells.
2. analyze the working principles of batteries, fuel cells.
3. express harnessing of solar energy with different solar cells.

Learning material

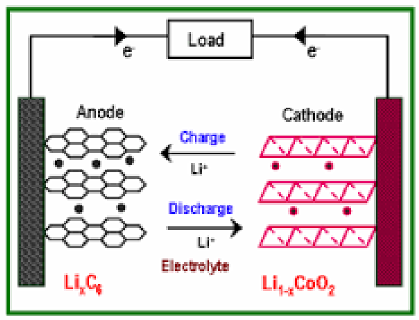
Secondary cells or Storage cells:

The cell in which the cell reaction is reversible is called a Secondary cell. A secondary cell works like an electrochemical cell (Galvanic cell) as well as an electrolytic cell. During working as galvanic cell, secondary cell supplies the electrical energy and forms the products from reactants. If electrical energy is supplied in reverse direction to the secondary cell, then it works as electrolytic cell and the reactants are generated at the electrodes from the products i.e. the cell is again ready for supply of electrical energy. Hence these cells are used for storing electrical energy and named as Storage cells.

This advantage of secondary cells find many applications in automobile industry, as inverter battery and to store electricity produced by photovoltaic systems.

Lithium ion battery:

Lithium ion batteries (Li-ion batteries) can be rechargeable hence they are used as storage batteries. In this battery, lithium is taken in a state of intercalation compound both in anode and cathode. $LiCoO_2$ acts as cathode and porous carbon acts as anode. Lithium salts such as $LiPF_6$ or $LiBF_4$ is taken in an organic solvent such as ethylene carbonate. Anode and cathode are separated by a membrane.



During discharge, the current flows within the battery from the anode to cathode and Li^+ ions move from graphite to cobalt oxide through the non-aqueous electrolyte.

During charging, by an external power source, negative terminal is connected to anode of the cell and positive terminal is connected to cathode and Li^+ ions move from cobalt oxide to graphite through the non-aqueous electrolyte.

The cathode half-cell reaction: $LiCoO_2 \leftrightarrow Li_{1-x}CoO_2 + xLi^+ + xe^-$

The anode half-cell reaction is: $xLi^+ + xe^- + 6C \leftrightarrow Li_xC_6$

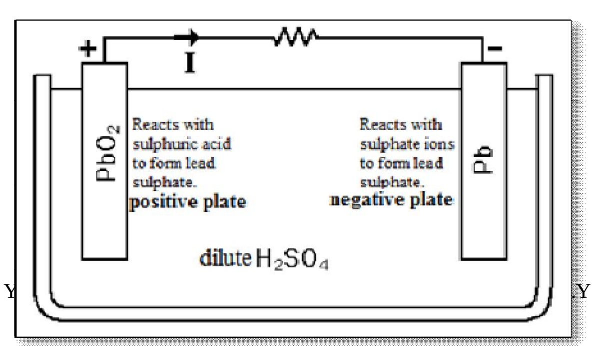
Overall reaction is: $LiCoO_2 + 6C \leftrightarrow Li_{1-x}CoO_2 + Li_xC_6$

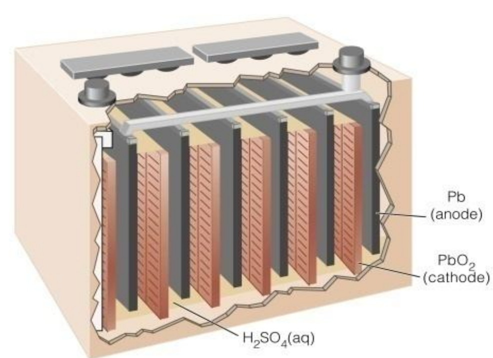
Advantages:

1) Li-ion batteries have high energy-to-weight ratio, hence they are portable.
2) Li-ion batteries have high slow-discharge when not in use.

Application: Li-ion cells are used in mobile phones, laptops and other electronic equipment.

Lead acid storage cell:





Secondary cells can be recharged. An automobile battery—the lead storage battery—is a rechargeable battery. The 12V version of this battery contains six voltaic cells, each generating about 2 V. The lead storage battery can produce a large initial current, an essential feature when starting an automobile engine.

The anode of a lead storage battery is metallic lead. The cathode is also made of lead, but it is covered with a layer of compressed, insoluble lead(IV) oxide, PbO_2.The electrodes are arranged alternately and separated by thin fiberglass sheets in aqueous sulfuric acid.

During cell discharge *(When cell supplies energy)*:

When the cell supplies electrical energy, the lead anode is oxidized to lead(II) sulfate. This lead(II) sulphate is an insoluble substance that adheres to the anode electrode surface. The two electrons produced per lead atom move through the external circuit to the cathode, where $PbO_2$is reduced to Pb^{2+} ions that, in the presence of H_2SO_4, also form lead (II) sulfate.

Anode, oxidation: $Pb + SO_4^{2-} \rightarrow PbSO_4 + 2e^-$

Cathode, reduction: $PbO_2 + SO_4^{2-} + 4H^+ + 2e^- \rightarrow PbSO_4 + 2H_2O$

Net reaction: $Pb + PbO_2 + 2H_2SO_4 \rightarrow 2PbSO_4 + 2H_2O$

During cell recharge:

A lead storage battery is recharged by supplying electrical energy. The $PbSO_4$coating on the surfaces of the electrodes is converted back to metallic lead and PbO_2 and sulfuric acid is regenerated. Recharging this battery is possible because the reactants and products remain attached to the electrode surface.

Anode, oxidation: $PbSO_4 + 2H_2O \rightarrow PbO_2 + SO_4^{2-} + 4H^+ + 2e^-$

Cathode, reduction: $PbSO_4 + 2e^- \rightarrow Pb + SO_4^{2-}$

Net reaction: $2PbSO_4 + 2H_2O \rightarrow Pb + PbO_2 + 2H_2SO_4$

Advantages:

1. When the automobile (say car) starts running, it can be easily recharged.
2. It has constant potential 12V
3. It is portable and inexpensive.
4. Low maintenance requirements — no electrolyte to fill.
5. Capable of high discharge rates.

Disadvantages:

1. Environmentally unfriendly — the electrolyte and the lead content can cause environmental damage.
2. Lead storage batteries have the disadvantage of being large and heavy.

Maintinance free Lead-acid battery:

Introduction: In lead-acid battery the water levels decreases during utilization hence by checking the water levels in the battery, distilled water is added by opening the valves that are present in the battery. This type of lead acid batteries is called flooded batteries and which requires maintenance.

Maintenance free lead acid batteries are generally called by valve-regulated lead-acid battery (VRLA battery) or sealed lead-acid (SLA) or gel cell.

Construction:

VRLA cells have the same chemistry as that of flooded battery consists of lead as anode and lead oxide as cathode and which are suspended in dilute sulfuric acid.

There are two types of VRLA batteries, AGM and Gel.

Gel cells add silica dust to the electrolyte, forming a thick putty-like gel. These are sometimes referred to as "silicone batteries". AGM (Absorbent Glass Mat) batteries feature fiberglass mesh between the battery plates which serves to contain the electrolyte.

Mechanism:

In all lead-acid battery designs, charging current must be adjusted to match the ability of the battery to absorb the energy.

If the charging current is too high, electrolysis will occur, decomposing water into hydrogen and oxygen, in addition to the intended conversion of lead sulfate and water into lead dioxide, lead, and sulfuric acid (the reverse of the discharge process.)

In VRLA they retain in the battery as long as pressure maintained in the safe levels. Usually the hydrogen and oxygen recombine within the battery itself to form water sometimes with the help of a catalyst.

However, if the pressure exceeds safety limits, safety valves open to allow the excess gases to escape, and in doing so regulate the pressure back to safe levels (hence "Valve-Regulated" in "VRLA").

But in flooded battery these gases are allowed to escape, hence the battery will need to have water added from time to time.

Applications of VRLA batteries: VRLA's are mostly useful where discharging and charging cycles takes place at slower rate such as power storage applications.

1. These are used in Standby and Emergency Backup applications such UPS, emergency lightning and telephone switching etc.
2. These are used in Sail boats, electronics and electrical vehicles etc.

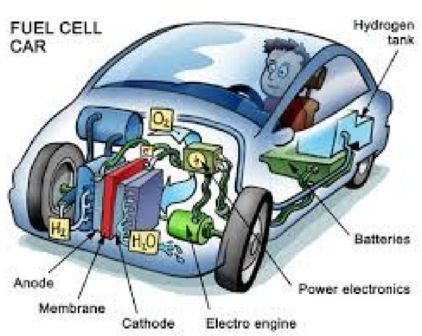
Limitation:

The main limitation of the VRLA design is that the immobilizing electrolyte also impedes the chemical reactions that generate current. For this reason, VRLAs have lower peak power ratings than conventional designs. This makes them less useful for applications like car starting batteries where usage patterns are brief high-current pulses (during starting) followed by long slow recharging cycles.

Fuel cells:

A fuel cell is an electrochemical "device" that continuously converts chemical energy into electric energy for as long as fuel and oxidant are supplied. The characteristics of fuel cells are a) high efficiency, ii) low noise levels and iii) free from thermal pollution

The efficiency of the fuel cell is higher in producing useful work than the electrical power plant using the same fuel. The energy produced by the fuel cell is also considered as green energy because usually the byproduct is water used for drinking purpose. Hence these are used in space vehicles for power supply and the water produced is useful for astronauts for drinking. It finds application in automobile industries by replacing the fossil fuels.



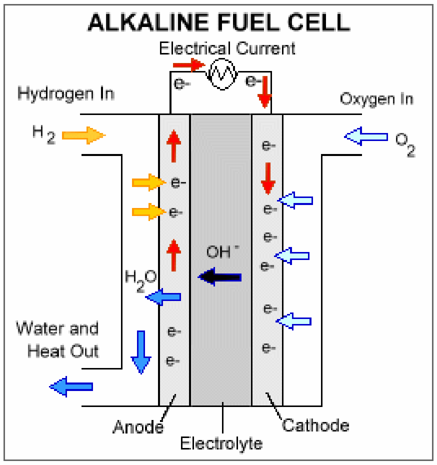
Hydrogen-Oxygen fuel cell:

H_2-O_2 fuel cell:

Hydrogen-Oxygen fuel cell has two electrodes made of graphite impregnated with finely divided Pt.

1. At anode hydrogen gas is passed and at cathode oxygen from air is supplied.
2. Anode and cathode are separated by proton exchange membrane which allows the flow of hydrogen ions.
3. The hydrogen enters the fuel cell at the anode. It is oxidized to hydrogen ions in presence of hydroxyl ions to form $H_2O$and the electrons travel through wires to cathode.
4. The oxygen enters at the cathode, usually from the air. The oxygen picks up the electrons that have completed their circuit.
5. The oxygen then combines with the H_2O and Hydroxyl ions are formed.

6. In the overall reaction hydrogen combines with oxygenin presence of KOH to produce water as byproduct.
7. Cells currently in use run at temperatures of 70–140 °C and produce about 1.24 V.



Reaction at anode: $2H_2 + 4OH^- \rightarrow 4H_2O + 4e^-$

Reaction at anode: $O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$

Overall reaction: $2H_2 + O_2 \rightarrow 2H_2O$ + Energy

Advantages of Fuel cells:

1. Noise and thermal pollution are low.
2. Maintenance cost is low.
3. The product H_2O is a drinking water source for astronauts.
4. The energy conversion is very high (75–82%).

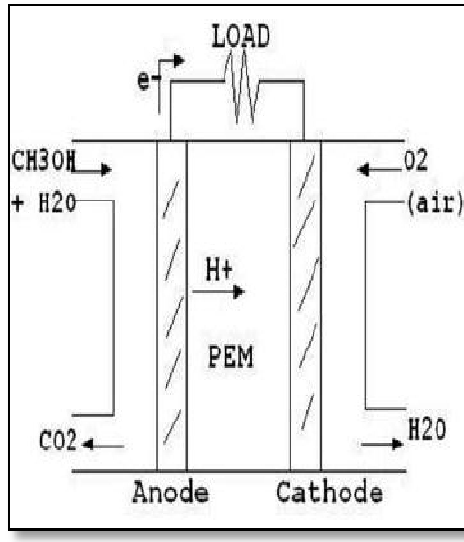
Applications of hydrogen oxygen fuel cell:

1. These are used as one of the energy sources in space vehicles.
2. These are also used in submarines, military vehicles etc.
3. Because of their light weight, these fuel cells are used in space crafts. And the exhausted H_2O is used as drinking water for astronauts.

Limitations:

1. The lifetime is not accurately known.
2. Platinum is used as catalyst. So the initial cost is high.
3. The distribution of hydrogen is not same all the time.
4. To use in automobiles, storage of hydrogen is the limiting factor. Not only has that, since hydrogen is the light weight gas, less hydrogen occupied more volume. So we cannot store enough fuel for to travel long distances.
5. If hydrogen gas contains carbon monoxide (if H_2 is derived from hydrocarbons, methanol, it generally contain CO), it will poison the Pt catalyst. So efficiency of the fuel cell decreases.

Direct Methanol-oxygen fuel cell (DMFC):



1. In this fuel cell, H+ ions are generated at anode using a mixture of methyl alcohol and H_2O.
2. Following reactions take place
   $CH_3OH + H_2O \rightarrow CO_2 + 6H^+ + 6e^-$ (at anode)
   $3/2\ O_2 + 6H^+ + 6e^- \rightarrow 3\ H_2O$ (at cathode)
   $CH_3OH + 3/2\ O_2 \rightarrow CO_2 + 2H_2O$ (Overall reaction)
3. The product of the reaction is carbon dioxide which is non-toxic.
4. It gives a voltage of 1.2V.
5. It is used in spacecrafts to have continuous power supply. It is also used in military in large scale for power production.

Advantages:
1. To overcome hydrogen storage problem, methyl alcohol mixed with steam is used as fuel source at anode. Since methyl alcohol is a liquid, we can transport and store it easily (where as it is not possible for hydrogen).
2. In the reaction between CH_3OH and H_2O, more H^+ ions (six) are produced. So we can load enough fuel for to travel long distances.

Limitation:
1. The waste product is CO_2 which is a greenhouse gas.
2. Some amount of methyl alcohol will pass through proton exchange membrane. This is called methanol crossover. This penetrated methanol will be oxidized at cathode without producing any electrons. As a result
   (a) Quantity of methyl alcohol stored will be reduced without producing electricity.
   (b) Efficiency of oxygen cathode will be reduced.

Solar energy:

Photovoltaic cell:

Photovoltaic (PV) cells convert the solar energy directly into electricity by using photovoltaic effect. PV based systems are commonly known as solar cells. The applications of photovoltaic system are enormous and out of those, utilization in satellite is important.

Examples: Monocrystalline silicon, Polycrystalline silicon, Cadmium telluride photovoltaic's, Copper indium gallium selenide solar cell, Gallium arsenide multijunction, Dye-sensitized solar cells, Quantum dot solar cell, Organic/polymer solar cells.

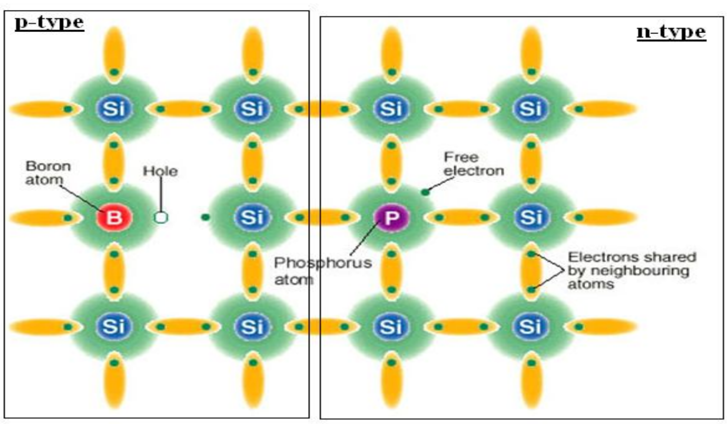
Theory or principle of PV cells:

Silicon can be made a semi-conductor by doping it with another element (called dopant), such as boron or phosphorous. Depending on the dopant, silicon can become either p-type or n-type semi-conductor.

Silicon has four valences. If IIIA group element (say Boron) is doped in it, Boron forms three covalent bonds only with silicon and leaves fourth bond vacant (say hole). So the added Boron impurity creates a hole in silicon crystal. To complete its octet, the boron doped silicon always wants to gain electron into the hole. This type of material is called p-type.

If VA group element (say Phosphorous) is doped in silicon, Phosphorous forms four covalent bonds with silicon and one unpaired electron was left in phosphorous. So the added Phosphorous impurity makes the silicon electron rich. So this silicon crystal is always ready to give its excess electron. This type of material is called n-type.

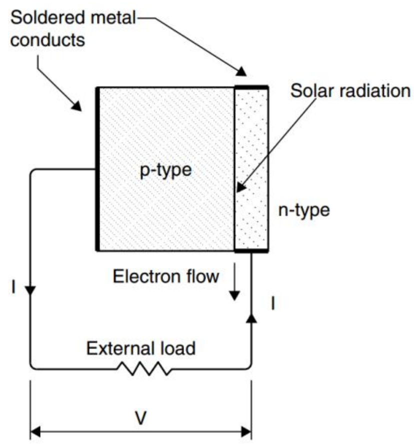
If n-type and p-type silicon crystals are connected, it forms a diode. A photovoltaic cell consists of series of p-n junction diodes.



p-n junction diode

Working of photovoltaic cell:

Photovoltaic cells capture the energy of sunlight, which is composed of photons. These photons contain an energy corresponding to their wavelengths in the solar spectrum.



Whenever a photon (photon with certain level of energy) strikes the n-type semiconductor, it moves the free electron to p-type semiconductor. So a hole is now created in n-type. Then the electrons from nearby atoms will move into this hole, and the process will continue until it reaches the external electrical circuit.

A solar panel (also solar module, photovoltaic module or photovoltaic panel) is a packaged, connected assembly of photovoltaic cells(which are connected in series). The solar panel can be used as a component of a larger photovoltaic system to generate and supply electricity.

Advantages of Photovoltaic solar energy:

1. Solar cells are easy to operate and need little maintenance.
2. There are no moving parts.
3. They have longer life.
4. They do not create pollution problem.
5. Their energy source is unlimited.
6. They can be easily fabricated.

Disadvantages:

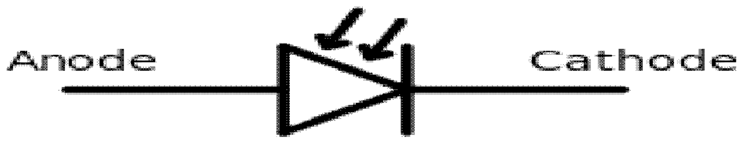
1. The cost of solar cell is quite high.
2. The output of a solar cell is not constant; it varies with the time of day and weather.
3. Amount of power generated is small.
4. Solar cells require more space for large scale production of electricity.

Photosensitizing diode:

- A photo sensitive diode functions just opposite of the LED.
- When current flows through a LED, it emits light.
- In photosensitive diode, the current flows on falling of light.
- When there is no light falls on the photosensitive diode then there is no flow current through it.

- Like a ordinary diode, photo sensitive diode also do not conducts during reverse bias but on getting light it conducts on reverse bias and works like a simple diode on forward bias.
- In this way it can be said that photosensitive diode is a reverse biased diode.

  In the fig. 1 graphical symbol of diode.



  - An arrow indicates the direction of light.
  - This reverse supply must not be greater than the capacity of the diode. If it rises from the 1/10 of its capacity than very small but constant current flows through the photo diode. This is known as DARK CURRENT.

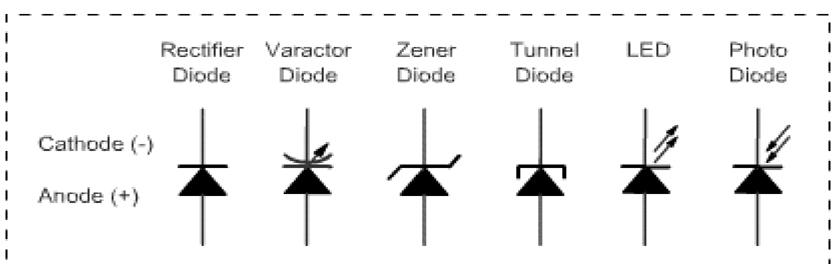
Applications:

- Photo diode has many functions. It is used in many types of alarms like burglar alarm, fire alarm etc.
- It is also used as a light operated switch.

Note:

Definition of photo diode:

Photo means light and diode means a device consisting of two electrodes.A photo diode is a light sensitive electronic device capable of converting light into a voltage or current signal. It works on the principle of photo generation.



Schematic Symbols for Diodes

Solar power plant (or) **Concentrating solar power (CSP)**:

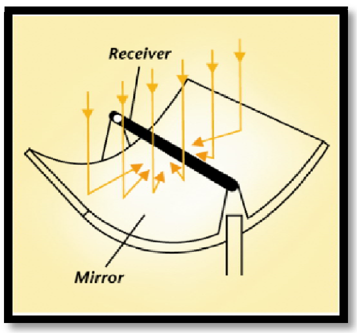
In solar power plants we use mirrors to concentrate (focus) the sun's light energy and convert it into heat. The heat is used to create steam which drives a turbine and generates electrical power. The plants consist of two parts:

one that collects solar energy and converts it to heat, and another that converts the heat energy to electricity.

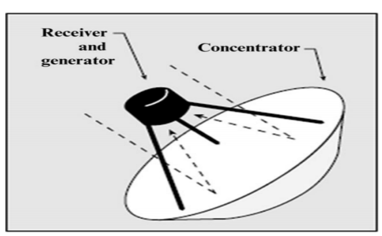
The following three types of methods are mainly in usage to collect sunlight.

1. Parabolic trough collector
2. Solar dish system
3. Solar power tower

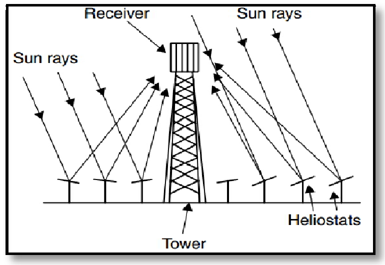
1. <u>Parabolic trough collector</u>: Trough systems use large, U-shaped (parabolic) reflectors (focusing mirrors) that have heat transfer fluid(like water)-filled pipes running along their center, or focal point, as shown in the following figure. The mirrored reflectors are tilted toward the sun, and focus sunlight on the pipes to heat the oil inside to as much as 400^{o}C. The hot oil is then used to boil water, which makes steam to run conventional steam turbines and generators.



2. <u>Solar dish system</u>: Dish systems use mirrored dishes (about 10 times larger than a backyard satellite dish) to focus and concentrate sunlight onto a receiver. As shown in the following figure, the receiver is placed at the focal point of the dish. The dish follows the motion of the Sun just as a Sunflower. The receiver contains heat transfer fluid, which moves the piston and turns crankshaft just like in automobile engines. This generates electrical energy.



3. <u>Solar power tower</u>: Power tower systems also called central receivers, use many large, flat heliostats (mirrors) to track the sun and focus its rays onto a receiver. As shown in the following figure, the receiver sits on top of a tall tower. The receiver consists of a heat transfer fluid which will get nearly 600^{o}C. The hot fluid will be utilized to generate steam and thereafter electricity. The heat transfer fluid has a capacity to store its heat for many hours. So the molten salt can be utilized to produce electricity after sunset or on cloudy days.



Advantages of solar power plant:

- Solar power is clean energy with little environmental impact, and does not release air pollutants or noise while it is being generated.
- Since the source of energy is Sun, we can install solar power plant anywhere on the earth which is not possible in case of hydraulic or nuclear or thermal power plants.
- With few moving parts in its system it has no mechanical corrosion and long life.

Disadvantages:

Installation costs are currently high. Generation of electricity depends on season and location conditions of the field.

UNIT-V

Assignment Cum Tutorial

Section - A

Objective Questions

1) The solvent used in Li-ion cells is ________ [ ]
(a) HCl (b) Distilled water (c) Organic solvent (d) Alkali

2) The anode used in Pb-Acid battery is _________ [ ]
(a) Pb (b) $PbSO_4$ (c) PbO_2 (d) H_2SO_4

3) The cathode in Li-ion cell is an intercalation compound of _ [ ]
(a) Graphite (b) H_2SO_4 (c) $PbSO_4$ (d) $LiCoO_2$

4) VRLA battery means ____________________

5) Match the following [ ]

List I (Electrolytes)		List II (Storage batteries)	
1)	H_2SO_4	A)	Lithium ion cell
2)	$LiBF_4$	B)	H_2-O_2 alkaline fuel cell
3)	KOH	C)	Lead-Acid accumulator

(a)1-C,2-A,3-B (b) 1-A,2-C,3-B (c) 1-B,2-A,3-C (d) 1-C,2-B,3-A

6) Which of the following statement is true? [ ]
(a)At cathode always oxidation takes place.
(b)At anode always oxidation takes place.
(c)At both the electrodes always first reduction takes place and then oxidation takes place.
(d) At anode always reduction takes place.

7) A photo voltaic cell converts __________energy to ____________ energy.

8) Solar reflectors contain____________ [ ]
(a) Metal surfaces (b) wooden surfaces
(c) **Mirror surfaces** (d) semiconductors

9) Solar cells convert solar energy to electricity by the mechanism of [ ]
(a) Photovoltaic effect (b) Photosynthesis
(c) Photo chemical reactions (d) Photo catalytic effect

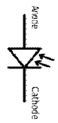
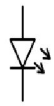
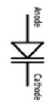
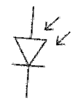
10) Select the incorrect statement from the following option. [ ]
(a) Fuel cells have high efficiency
(b) The emission levels of fuel cells are far below the permissible limits
(c) Fuel cells are modular
(d) **The noise levels of fuel cells are high**

11) The residual product discharged by the hydrogen-oxygen cell is [ ]
(a) Hydrogen peroxide (b) Alcohol
(c) **Water** (d) Potassium permanganate

12) The standard emf of the hydrogen-oxygen fuel cell is [ ]

(a) **1.23 V** (b) 2.54 V (c) 3.96 V (d) 0.58 V

13) Refer to this figure .Which symbol is correct for photo sensitive diode? [ ]

(a)  (b)  (c)  (d) 

SECTION-B

Descriptive questions

1. Define secondary cell.
2. What are fuel cells?
3. Write the principle equations of H_2-O_2 cell.
4. Write any four advantages of H_2-O_2 fuel cell.
5. What are the advantages of Pb-Acid batteries?
6. What is the principle of PV cell?
7. What is photo voltaic effect?
8. Write short note about solar tower.
9. Describe the construction of lead acid storage cell and explain how it works as a storage battery?
10. Define fuel cell. Explain the construction and working of H_2-O_2 fuel cell. What are advantages and limitations of the cell?
11. Explain the working principle of methanol-oxygen fuel cell with reactions. Discuss its applications and limitations.
12. How VRLA batteries working as maintenance free batteries? Explain the construction and working of the battery.
13. Explain the construction and working of photovoltaic cell.
14. Discuss the construction and working of photosensitizing diode.
15. Explain the following with neat diagram.

    (a) Parabolic trough. (b) Solar dish. (c) Solar tower.

Section C

1. The negative pole of a lead acid battery is made of_________ [ ]
   (a) Carbon (b) PbO_2 (c) $PbSO_4$ (d) Pb
2. During discharge of lead acid storage cell, the active material of both the positive and negative plates is changed to_______ [ ]
   (a) Pb (b) PbO_2 (c) PbO (d) $PbSO_4$
3. Which of following battery can you suggest for space shuttle? [ ]
   (a) H_2-O_2 fuel cell (b) VRLA
   (c) Lead -acid accumulator (d) Lithium ion batteries
4. Where would you most likely find a lead-acid battery? [ ]
   (a) In a mobile (b) In an inverter
   (c) In a digital wall clock (d) In a torch light.
5. Usually mobile phones run by the following electrochemical cells[ ]

(a) Primary cells (b) Lithium ion batteries (c) VRLA (d) Fuel cell

6. Which of the following statement is correct [ ]
   (a) Pb-Acid accumulator used in inverter is an example of secondary cell.
   (b)Leclanche cell used in electronic equipment works as a storage cell also.
   (c) Fuel cells used in space vehicles can be charged.
   (d) Dry cell is used as secondary cell.
7. Which of the following statement is false? [ ]
   (a) The concentration of H_2SO_4 decreases while the lead-acid cell is discharging.
   (b) The concentration of H_2SO_4 increases while the lead-acid cell is charging.
   (c) The concentration of H_2SO_4 is not constant during overall cycle of charging and discharging.
   (d) The concentration of H_2SO_4 remains constant.

Unit – VI

Green Chemistry

Objectives:

To introduce the students the importance of green chemistry and its applications of green chemistry.

Syllabus :

Introduction - Principles of green Chemistry, methods of green synthesis (supercritical fluid extraction and microwave induced methods), EWM (Electronic waste management), ZWT (Zero Waste Technology). Applications of green chemistry.

Course outcomes:

Students will be able to

- explain the need of green chemistry.
- explain the principles of green chemistry and suitable method for synthesis of green products.
- apply the green principles for e - waste management and zero waste technology

Introduction:

- Green chemistry is an approach to pollution prevention.
- It controls the pollution at the beginning of the process.
- "**Green chemistry is an approach to the design, manufacture and use of chemical products to reduce or eliminate chemical hazards".**
- Green chemistry is an essential program to protect human health and environment.

Need of Green Chemistry:

- Green chemistry aims to eliminate hazards right at the design stage. The practice of eliminating hazards from the beginning of the chemical design process has benefits for our health and the environment, throughout the design, production, use/reuse and disposal processes.

- It focuses on prevention of waste, less hazardous chemical syntheses, and designing safer chemicals including safer solvents.
- It focuses on the design of chemical products to safely degrade in the environment.

Principles of Green Chemistry:

Paul T. Anasthas and John Warner proposed the following twelve principles of Green Chemistry.

1. **Prevention**

   It is better to prevent waste than to treat or clean up waste after it has been created.

2. **Atom Economy**

   Synthetic methods should be designed to maximize the incorporation of all materials used in the process into the final product.

   % atom economy=formula weight of desired product x 100 / (sum of the formula weights of all the reactants used in the reaction.)

3. **Less hazardous chemical synthesis**

   Wherever practicable, synthetic methods should be designed to use and generate substances that possess little or no toxicity to human health and the environment.

   For example adipic acid is widely used in polymer industries for the manufacture of nylon, polyurethane etc. was earlier synthesized from benzene which is carcinogenic. In Green technology, it is being synthesized from glucose.

4. **Designing safer chemicals**

   Chemical products should be designed to affect their desired function while minimizing their toxicity.

For example, DDT is a powerful insecticide but it kills other useful insects also. So, it should be replaced with other substances that kill only the target organisms.

5. **Safer solvents and auxiliaries**

   The use of auxiliary substances (e.g., solvents, separation agents, etc.) should be made unnecessary wherever possible and harmless when used.

   This principle aims to use green solvents (water, super critical CO_2) in place of volatile organic solvents.

6. **Design for energy efficiency**

   Energy requirements of chemical processes should be recognized for their environmental and economic impacts and should be minimized.

   If possible, synthetic methods should be conducted at ambient temperature and pressure.

7. **Use of renewable feedstocks**

   A raw material or feedstock should be renewable rather than depleting whenever technically and economically practicable.

   For example renewable resources like solar energy, wind energy can be used in place of non renewable fossil fuels.

8. **Reduce derivatives**

   Unnecessary derivatization (use of blocking groups, protection/ deprotection, temporary modification of physical/chemical processes) should be minimized or avoided if possible, because such steps require additional reagents and can generate waste.

9. **Catalysis**

   Catalytic reagents (as selective as possible) are superior to stoichiometric reagents.

Suitable catalyst must be used for the chemical reaction to proceed in lesser time and that gives high yield.

10 . **Design for degradation**

Chemical products should be designed so that at the end of their function they break down into harmless degradation products and do not persist in the environment. Biodegradable products must be preferred.

For example, DDT is an effective pesticide but its stability in the environment causes several hazards.

11. **Real-time analysis for pollution prevention**

Analytical methodologies need to be further developed to allow for real-time, in-process monitoring and control prior to the formation of hazardous substances.

12. **Inherently safer Chemistry for accident prevention**

Substances and the form of a substance used in a chemical process should be chosen to minimize the potential for chemical accidents, including releases, explosions, and fires.

Methods of Green Synthesis or Green Reactions

Chemical synthesis that is consistent with the goals of green chemistry is called Green synthesis. The basic idea of cleaner production is to increase the production efficiency and to reduce the use and generation of hazardous substances and bi-products.

Green Synthesis is possible only by replacing the organic solvents like pyridine, benzene toluene etc. as much as possible by water or to eliminate the use of solvents altogether.

Super Critical Fluid Extraction Method (SFE)

- Generally organic solvents have been used for the extraction of compounds like caffeine, cholesterol etc.

- But these solvents pollute air, land and water.
- To avoid the pollution, SFE method was developed.
- Super critical fluid has combined properties of liquid and gas.
- Super critical fluids are produced by heating a gas above its critical temperature or compressing a liquid above its critical pressure.
- Super critical fluids have both the gaseous property of being able to penetrate any material and the liquid property of being able to dissolve materials into their components.
- The most commonly used SCF is CO_2 because of its solubilizing property similar to organic solvents with lower critical temperature and critical pressure.
- Water can also be used as SCF.
- The basic principle of SCF extraction is that when the feed material is contacted with SCF then the volatile substances will separate into super critical phase.
- After dissolution of soluble material, the SCF containing dissolved substances is removed from the feed material.
- The extracted component is completely separated from the SCF by changing temperature and pressure.
- The SCF may be recompressed to the extraction conditions and recycled.

Advantages of SCF Extraction process:

1. Dissolving power of SCF is controlled by pressure or temperature.
2. It is relatively a rapid process.
3. Quality and yield of the product can be increased.
4. SCF is easily recoverable from the extract due to its volatility.
5. SCF is non destructive process.
6. Separation of the fluid substances from the product is relatively easy and the solvent residues in the product are small.

Applications of Super Critical Fluid Extraction:

1. It is used for the extraction of essential oils, flavones and some natural products from plants.
2. It is used for the production of de-nicotined tobacco.
3. Used in the removal of caffeine from coffee.
4. Used in pharmaceutical industry for production of active ingredients from herbal plants.
5. Used in the extraction of bi-products from polymer components.
6. Used in purification of contaminated oils.

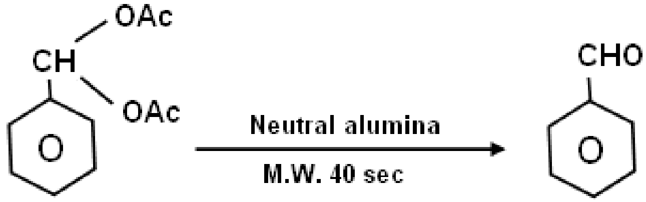
Microwave induced method for green synthesis:

- Microwaves are used for heating.
- Their wave length is 1 cm to 1m.
- Polar molecules absorb Microwaves and non polar molecules are inert to Microwaves.
- In absence of electric field, the polar molecules are in Brownian motion.
- But in presence of electric field, all the polar molecules are lined up together in the same direction.
- As the field oscillates, their orientation changes rapidly leading to homogeneous heating.

Microwaves are used to carry out organic reactions. There are 3 types.

1. Microwave – assisted reactions in organic solvents.
2. Microwave – assisted reaction in aqueous phase.
3. Microwave – solvent free reactions (solid state reactions).

For example Deacylation



Use of microwaves irradiation reduces the time for Deacylation and the yields are good.

Advantages:

1. It is a clean, economical and safe procedure.
2. Rapid and homogeneous heating lead the reaction very fast.
3. High purity products are obtained.
4. Good yield is obtained.

Limitations:

Sometimes solvents reach their boiling points, leading to explosion.

Zero Waste Technology:

In this concept, a waste product is said to be zero waste technology, when a byproduct or waste product of any unit is used as raw material (or starting material) for another unit.

Examples:.

- Molasses generated in sugar industry is used as raw material in manufacturing of alcohol.
- Bagasse obtained as solid waste in the sugar industry can be utilized as a raw material for manufacturing of paper and as a bio sorbent in treatment of waste water.
- Ash produced in thermal power stations can be used in manufacturing of bricks and as an adsorbent in waste water treatment.
- CO_2 produced in industries can be used as a blowing agent in manufacturing foam materials instead of using harmful chlorofluoro carbons.
- Agricultural byproducts can be used in manufacturing of biodegradable polymers.

Electronic Waste Management :

- Electronic waste or e-waste is a new type of waste that has emerged in the recent years due to fast development in the field of electronics.

- E-Waste consists of obsolete telecommunication devices, reprographic devices, security devices, refrigerators, air-conditioners, micro-waves, and other electrical and electronic gadgets which add to the waste stream.

- PC's are going to create a big solid waste management problem in India.
- PC scrap in the form of monitors, printers, keyboards, CPU's, floppies, CD's type writers, PVC wires have already started piling up that are going to increase enormously in the coming years.
- Its qualitative characterization shows it to be very complex consisting of several hazardous constituents that can danger to human health.

The toxic and hazardous substances are as follows:

- Lead and cadmium in circuit boards.
- Lead oxide and cadmium in monitor cathode ray tubes (CRT'S)
- Mercury in switches and flat screen monitors.
- Cadmium in computer batteries.
- Brominated flame retardants on printed circuit boards.

Management of E-Waste:

- It has serious legal and environment implications due to the toxic nature of the waste.
- These materials are complex and difficult to recycle in a safe manner even in developed countries.
- The recycling of computer waste requires sophisticated technology and processes, which are not only very expensive, but also need specific skills and training for operation.
- Computer scrap in our country is managed through product reuse, conventional disposal in landfills, incineration and recycling.
- However, the disposal and recycling of computer waste in our country are still not safe and produce environmental and health hazards.

Engineering Applications of green chemistry:

- Engineers apply scientific and engineering principles to the design of manufacturing and combustion processes to reduce air pollutant emissions to acceptable levels.

- Engineers have developed various air pollution dispersion modes to remove vehicle gases like NO_2, SO_2, and other air pollutants.
- Improving industrial processes to eliminate waste and reduce consumption of organic solvents.
- By using biotechnology processes, the biomass is converted into useful products by the action of enzymes.
- Preparation of bio ethanol is an ecofriendly process that can be used as the gasoline replacement.
- With the help of bacteria, yeast and other microorganisms, many products are being prepared. These processes are less expensive, ecofriendly and more productive.
- Pesticides like DDT should be replaced by compounds that are less harmful and destroy only the target organisms.
- Biopolymers produced from byproducts of starch industry are used as packing material.
- Engineers are trying their level best to develop many such ecofriendly processes which keep the plant earth in safe position.

Unit – VI

Assignment-Cum-Tutorial Questions

SECTION-A

Objective Questions.

1. One of the following is a concept of green chemistry [ ]
   a. Use of chemicals that are harmful
   b. Improper technical designing
   c. Production of by products in large amounts
   d. Use of recycled or recyclable products

2. Green chemistry is called [ ]
   a. Sustainable Chemistry
   b. Un sustainable Chemistry
   c. Developing Chemistry
   d. Conceptual Chemistry

3. Physical Character of SCFs [ ]
   a. Liquid
   b. Gas
   c. Combination of liquid and gas
   d. Vapour

4. Which of the following is SCF [ ]
   a) Benzene b) Toluene c) CO_2 d) Petroleum ether

5. Which of the following is not one of the twelve principles of green chemistry? [ ]
   a) Using high temperatures to speed up reactions
   b) Minimising toxic reagents used in a synthesis
   c) Maximisation of atom economy
   d) Minimising the use of solvents

6. Which of the following is the greenest solvent? [ ]
   a) Formaldehyde b) Benzene c) Ethanol d) Water

SECTION-B

Descriptive questions

1. Define green chemistry.
2. Discuss the need of green chemistry.
3. What is a Super Critical Fluid? Give an example.
4. What is the aim of Integrated Waste Management?
5. Write the short note on causes of E-waste.
6. What is the concept of zero waste technology?
7. Discuss any six applications of green chemistry.
8. What is the concept of green chemistry and its applications to the industry?
9. Explain briefly about the methods for green chemistry.
10. Write notes and advantages and applications of Micro Wave Induced method.

11. What are the main advantages and applications of Zero Waste Technology?
12. Mention engineering applications of green chemistry.
13. Give brief discussion about the Electronic waste management.

Section C

A. Level one questions:

1. What is an atom economy?
2. What are the examples for Super Critical Fluid?
3. State and explain any six principles of green chemistry.

B. Level two questions:

1. Write the characteristics of Super Critical Fluid.
2. What are the main advantages of Microwave induced method in green chemistry?