Chemistry important Questions solutions.

MODULE-1

1) What are electrochemical sensors? Explain the principle and working of electrochemical sensors and mention the applications of electrochemical sensors.

ANS: - Sensors which convert the effect of electrochemical reaction between analyte and electrode surface into a useful signal are known as electrochemical sensors.

Working principle-

Electrochemical sensors use electrodes as the transducer component. Transducer of an electrochemical component consists of working or sensing electrode, electrolyte, counter electrode, and reference electrode.

The main steps involved in the working of an electrochemical sensors are as follows

1. Diffusion of the analyte to the electrode/electrolyte interface (in the liquid phase)
2. Adsorption on to the electrode surface.
3. Electrochemical reaction with electron transfer.
4. Deposition of the products
5. Diffusion of the products away from the reaction zone to the bulk of electrolyte.

Applications of Electrochemical sensors

1. Electrochemical sensors used for the detection of blood glucose
2. Electrochemical sensors are used for pH measurements
3. Used to detect pesticides
4. Used in the detection of hydrocarbon pollutants.
5. They are used in soil parameter analysis, evaluation, and in agriculture applications.
6. The oxygen sensor is used for detection of dissolved oxygen in water boiler and to monitor dissolved oxygen concentration in metal melts, glasses and in hydrogen fuel.
7. They are used in security and defence applications like detection of toxic gases, warfare agents etc

2) Discuss the working principle and applications of Conductometric sensors.

ANS: - Conductometric Sensors: Conductometric sensors are two electrode devices, measures the electrical conductivity in sample solution between two electrodes.

Principle

The electrical conductance in accordance with ohms law which states that the strength of current (I) passing through conductor is directly proportional to potential difference & inversely to resistance .

$I = V / R$

Electrical conductivity of an electrolyte solution depends on
1. Type of ions (Cations, anions, singly or doubly charged)

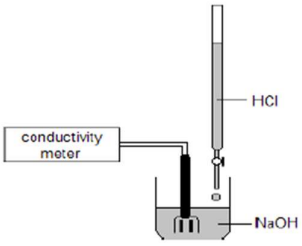
2. Concentration of ions

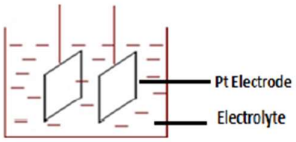
3. Temperature

4. Mobility of ions

Working:

Electrodes used in conductivity sensor are called as conductivity cell. It is used to measure the change in electrolyte conductance of the solution during replacement of ions of a particular conductivity by ions of different conductivity. It is made of two platinum foils with unit cross sectional area and unit distance between them.





Application:

•Mmonitoring of water quality.

• Detection of gas and vapor

 Analysis of biochemical compounds

 Measurement of ionic strength and pH levels in solutions

 Food and beverage industry.

3) Discuss the working principle and applications of optical sensors.

ANS: - Optical Sensor

Optical sensors are devices that use light and converts in to electric signals for detecting and measuring a sample.

Principle: When a monochromatic Light is passing through a sample, the change in the light in the form of absorbance, photoluminescence and chemiluminescence takes place, and it is obtained in the form of electromagnetic spectrum, having multiple properties of the sample.

The electromagnetic spectrum for analysis through photo detector, followed by display system.

Application:

- Computer, laptop, photocopy machine, light fixtures, photographic flashes, etc.
- Optical sensors are widely used in image processing which detects the objects.

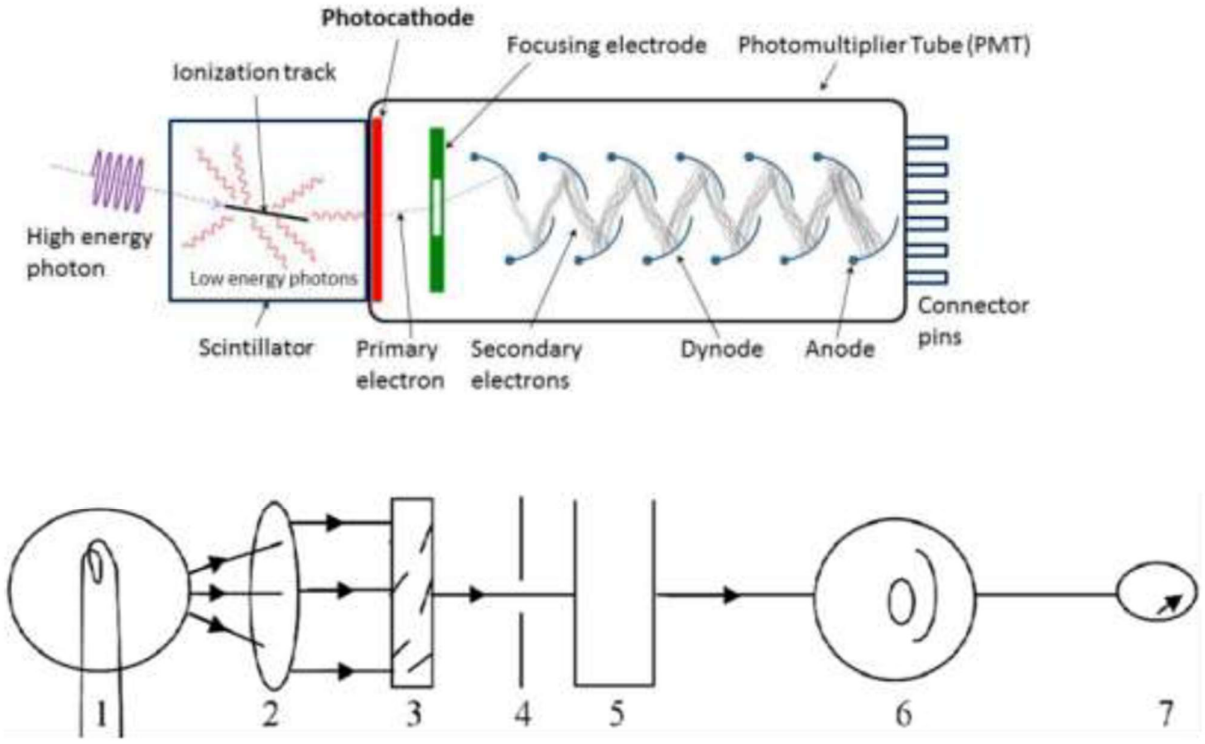


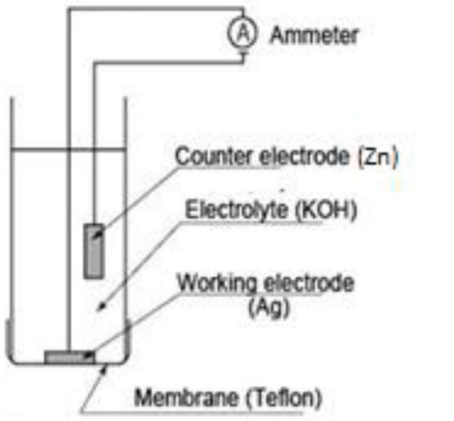
Fig.1.6 Components of Colourimetric Sensors

4) Explain electrochemical sensors application in the measurement of Dissolved Oxygen (DO).

ANS: Electrochemical Sensor for the measurement of Dissolved Oxygen (DO)

Introduction: There are several types of electrochemical sensors for DO measurement, including amperometric, polarographic, and galvanic sensors. Optical sensors like luminescence-based, fluorescence-based, and absorption- based sensors.

Construction: The amperometric sensors consists of the following components such as
Counter electrode – Inert metal such as Ag
Working electrode- Zn/Pb
Electrolyte- KOH
Membrane –Teflon membrane



Sensor for DO measurement

Working – When the electrode assembly is dipped in sample to measure its DO, the anode undergoes oxidation with the liberation of electron

Anode(Zn): Oxidation $2\,Zn \longrightarrow 2\,Zn^{2+} + 4e^-$

At Cathode: DO undergoes reduction in presence of electrons results hydroxyl ions.

Cathode(Ag): Reduction $O_2 + 4e^- + 2H_2O \longrightarrow 4OH^-$

The overall reaction is:

Overall: $2\,Zn + O_2 + 2H_2O \longrightarrow 2\,Zn(OH)_2$

The current produced due to the reduction of oxygen at cathode is proportional to the partial pressure of oxygen the sample.

5) What is battery? Give the classification of batteries with example.

ANS:

BATTERY: A battery is a device that consist of two or more galvanic cell connected in series or parallel or both, which converts chemical energy into electrical energy through redox reaction.

CLASSIFICATION OF BATTERIES:

The batteries are classified as

1. **Primary battery or primary cells**: A battery which cannot be recharged, cell reactions are irreversible and discarded when the battery has delivered all its electrical energy. Egs; dry cell or Zn-MnO_2 Cell, Li-Mno_2 cell

2. **Secondary battery**: A battery which can be recharged, cell reactions are reversible and A battery which after discharging, can be recharged. Egs: Lead storage cell and nickel cadmium cell.

3. **Reserve Batteries**: In reserve batteries, one of the components is stored separately and is incorporated into the battery when required. Egs: Mg-AgCl and Mg-CuCl battery.

6) Describe the construction and working of Lithium-ion battery. Mention its applications.

ANS: <u>Li-ion battery: (Secondary battery)</u>

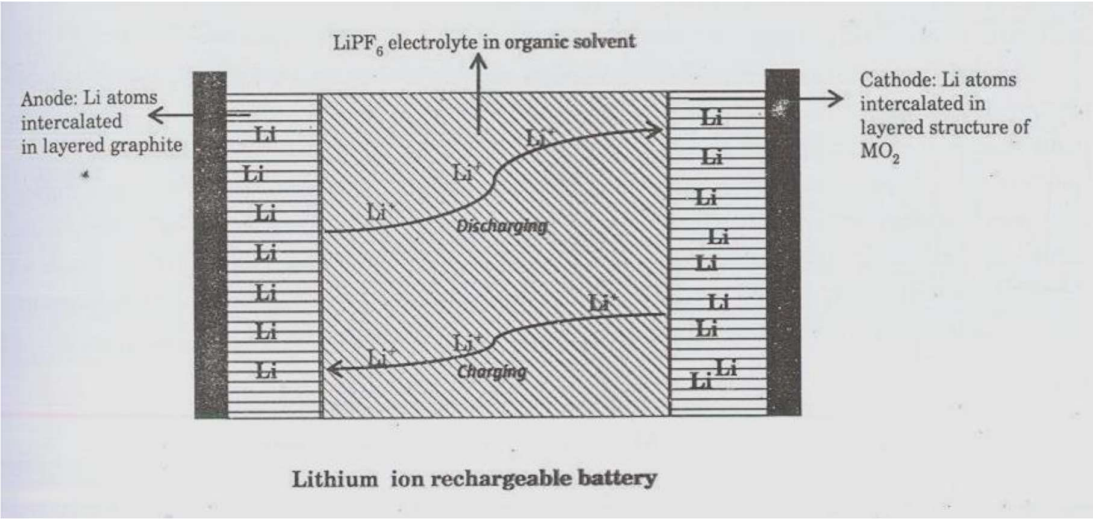
Construction of Li-ion battery

1. The Anode: Lithium atoms intercalated in layered graphite / Carbon metal

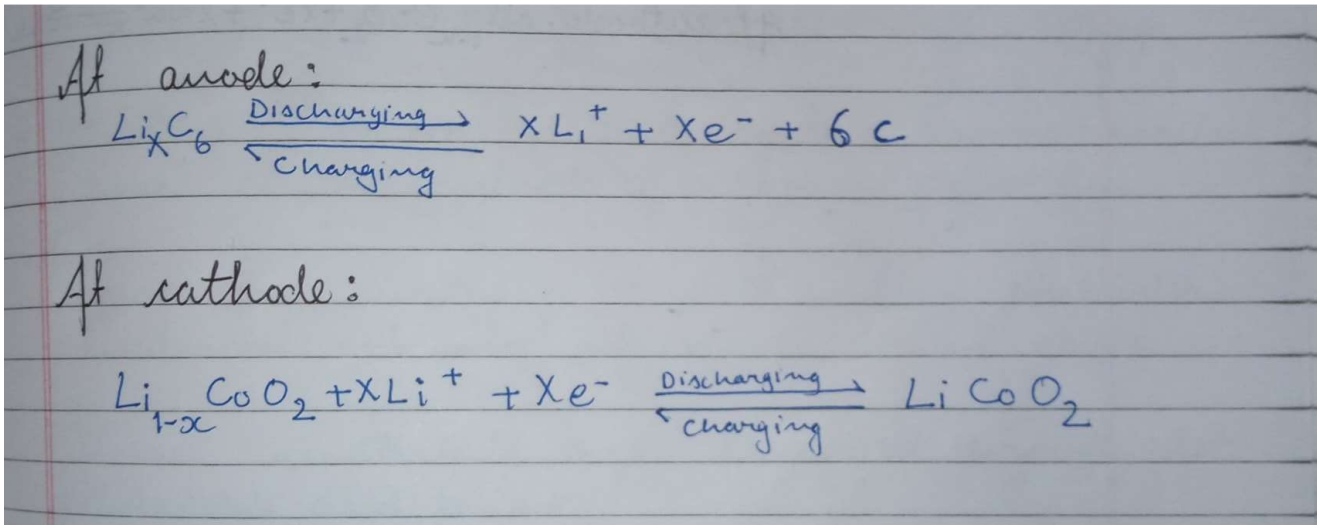
2. The Cathode: Lithium atoms intercalated in layered structure of MO_2 (Metal Oxide)

3. The Electrolyte: The electrolyte is lithium salt such as $LiPF_6$ dissolved in organic solvents (Ethylene carbonate – dimethyl carbonate)

4. The separator: Made of Poly propylene membrane.



Cell representation: Li │Li^+, C/ $LiPF_6$ in organic solvents │ Li-MO_2 Electrode

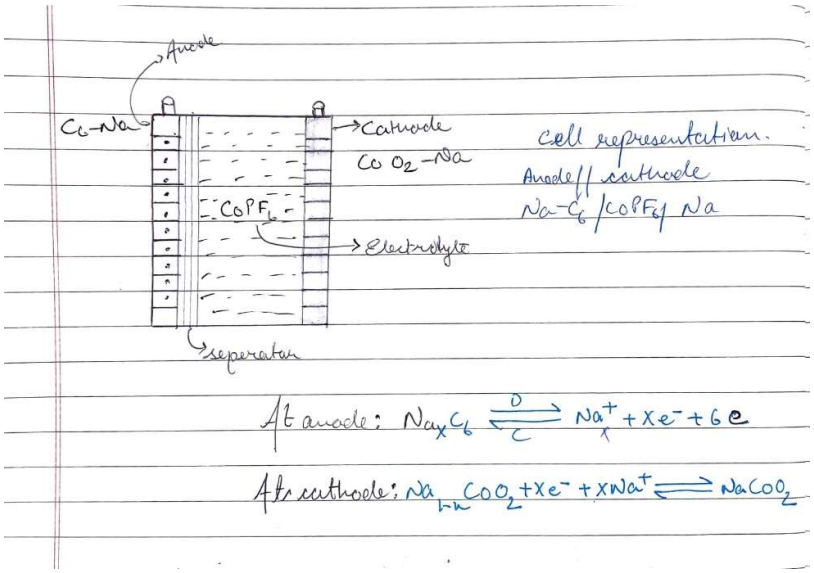


Applications: Used in cell phone, Laptops, Electrical vehicles, Aerospace applications, Portable LCD TV etc.

7) Describe the construction and working of sodium –ion battery. Mention its applications

ANS: <u>Na-ion battery</u>:

Construction: -
Anode: Sodium Hard Carbon Material (Na_xC_6)
Cathode: Sodium Layered Transition Metal Oxides ($Na_{1-x}MO_2$)
Electrolyte: Sodium Salts ($NaPF_6$) Dissolved in Polar Organic Solvents
Separator: Porous poly propylene Separator



Applications:

- Electric vehicles
- Energy storage systems for solar, wind
- Power backup in electric utilities
- Portable LCD TV, CD player.

8) What are disposable sensors? Mention the advantages of disposable sensors.

ANS:

Disposable sensors

Disposable sensors are typically made of low-cost materials and easy-to-use sensing devices designed for short term or rapid single-point measurements.

Advantages of Disposable Sensors over Classical Sensors:

- Cost-effective: Disposable sensors are typically cheaper than classical sensors.
- Convenient: Disposable sensors do not require calibration or maintenance.
- Hygienic: Disposable sensors can help reduce the risk of cross contamination in medical and food safety applications.
- Portable: Because disposable sensors are typically smaller and lighter than classical sensors.
- Rapid testing: Disposable sensors can provide results quickly, allowing for faster decision-making.
- Reduced waste: Because disposable sensors are designed to be used once and then discarded.

9) Discuss the detection of a bio-molecule ascorbic acid using disposable sensor and write the electro oxidation reaction.

ANS: Ascorbic acid, also known as Vitamin C, is an essential well-known antioxidant and essential nutrient in human diets and is also used as a food preservative. The detection of ascorbic acid can be important in various fields, such as food safety and medical diagnosis.

Working principle- It consists disposable strip. This consists of sensing electrode with active material capable of oxidation reaction, counter electrode, reference electrodes are printed on the disposable strip using printing technology.
The ascorbate oxidase enzyme immobilized on a screen-printed carbon electrode with poly ethylene glycol and diglycidyl ether as a crosslinking agent as sensing electrode.
The sensing electrode oxidizes the ascorbic acid in to dehydro ascorbic acid
Concentration ascorbic acid is determined from the change in potential of the oxidation process.

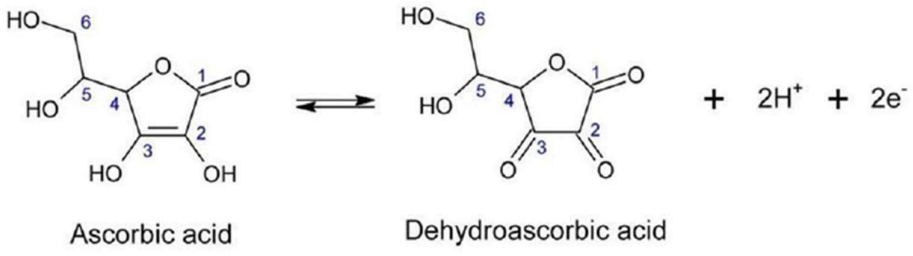


Fig: 1.18 Oxidation of Ascorbic acid

10). Explain the detection of Herbicide-Glyphosate with reactions.

ANS: **Detection of pesticide such as Glyphosate by electrochemical oxidation method**

One of the most commonly used pesticides is glyphosate. Glyphosate has the ability to attach to the soil colloids and degraded by the soil microorganisms. As glyphosate led to the appearance of resistant species, the pesticide was used more intensively. As a consequence of the heavy use of glyphosate, residues of this compound are increasingly observed in food and water. Recent studies reported a direct link between glyphosate and chronic effects such as tetrogenic, tumorigenic.

Electrochemical Sensor for Glyphosate Detection

The sensor is a silicon- based chip comprising of three-electrode system. It is fabricated by electro deposition technique.
Working Electrode: A gold electrode of 4 mm diameter coated with 200nm thickness gold nanoparticles
Counter electrode: A gold electrode of 4 mm diameter coated with 20nm thickness gold nanoparticles
Reference Electrode: Ag/AgCl/Cl-
Electrolytes are added to increase the conductivity of the solution and minimizes the resistance between the working and counter electrode.

Working:

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

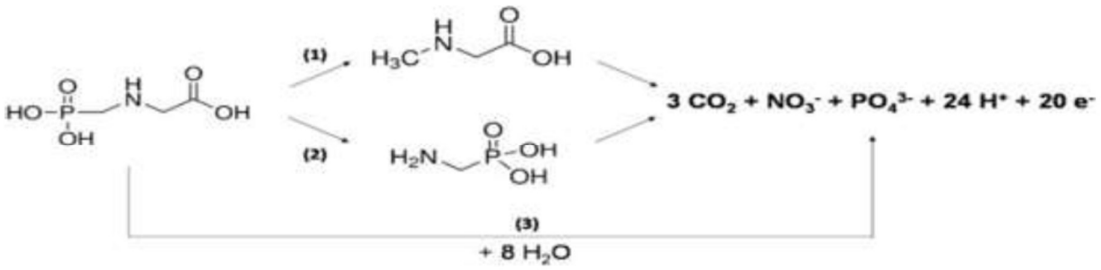


Fig:1.19 Electrochemical oxidation of Glyphosate

MODULE 4

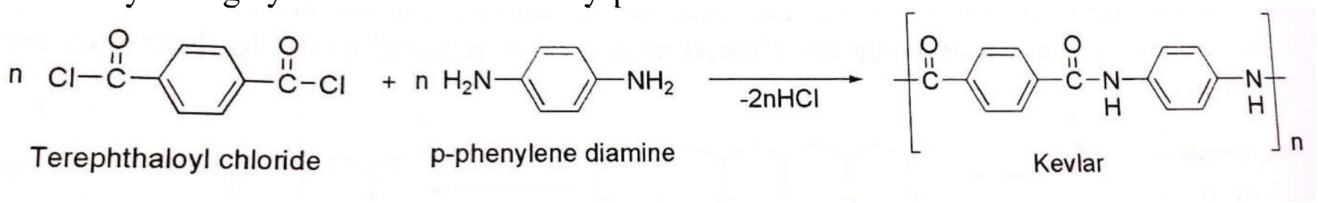
4) Give the Synthesis of Kevlar. Mention its properties and applications.

ANS:

Kevlar fibres:

Synthesis

Kevlar is synthesized in solution from the monomers of Terephthaloyl chloride (1,4 benzene dicarbonoyl chloride) & Para Phenylene diamine (1,4-phenylenediamine) in a condensation reaction yielding hydrochloric acid as a by-product.



Properties	Applications
Kevlar is crystalline, light weight and nonflammable.	Used in reinforcement material for some tyres.
Resistant to heat, impact and scratch.	Used in making of light weight boat hulls and aerospace industry.
Good Chemical resistance.	Used in formula one racing car .
Good tensile strength.	Used in bullet proof vests and combat helmets.
Abrasion & Corrosion resistant	Used in making puncture resistant tyres

5) Give the synthesis of graphene oxide. Mention its properties, and commercial applications.

ANS:

Graphene Oxide: -

Graphene is an allotrope of carbon made of a single layer carbon atoms that are bonded together in a repeating pattern of hexagons.

Graphene oxide is an oxidized form of graphene. It is obtained by treating graphene with strong oxidizers and acids.

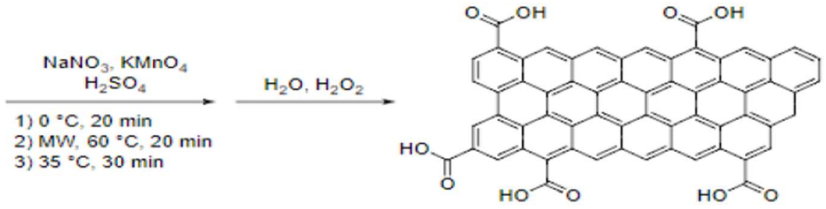
Preparation of Graphene Oxide: - (Hummer's Method)

 Take graphene (2gm) and Sodium Nitrate ($NaNO_3$) (2gm) were combined with H_2SO_4 (90ml) and stirred for 30 min in an ice bath.

 For the resulting mixture add $KMnO_4$ (10gm) and the solution was then kept for 2h.

 Then add deionized water (200ml) and H_2O_2 (12ml) slowly to the above solution, then the resulting solution was wash with HCl (300ml 10%).

 The obtained product was dried gives graphene oxide powder.



Graphene

Graphene Oxide

Properties of Graphene Oxide: -

 High thermal conductivity.

 High electrical conductivity.

 High elasticity and flexibility.

 High hardness.

 High resistance....

 Ionizing radiation is not affected.

 Able to generate electricity by exposure to sunlight.

 Transparent material.

Commercial Applications of Graphene Oxide: -

 Electronic devices.

 Energy storage devices.

 Bio- sensors.

 Biomedical applications.

 Super capacitors.

 Membranes, catalysts, and water purification.

6) What is Photovoltaic (PV) cell? Explain the construction and working of PV cell. Mention its advantages and disadvantages.

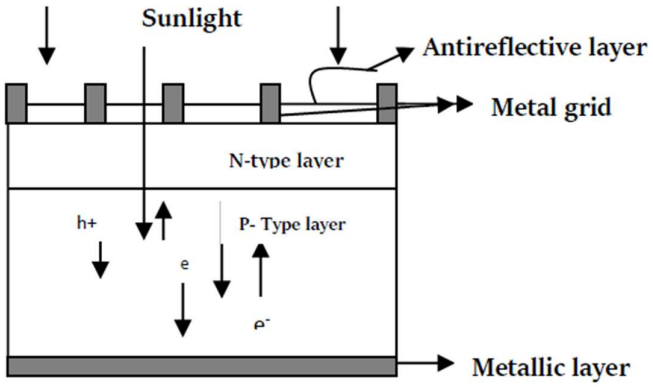
ANS: Photovoltaic Cells: -

Photovoltaic cells are semiconductor device which convert solar energy into electrical energy.
Photovoltaic cells can generate electricity as long as Sun light is available.

Construction and working of Photovoltaic cells: -
Photovoltaic cell is composed of a thin mater consisting of an ultra-thin layer of phosphorous doped [n-type] silicon on the top of boron doped [p-type] silicon. Hence P-n junction is formed b/w the two.
 A metallic grid forms one of the electrical contacts of the diode and allows light to fall on the semiconductor b/w grid lines.

 An antireflective layer b/w the grid lines increase the amount of light transmitted to the semiconductor.

 The cells other electrical contact is formed by a metallic layer on the back of the solar cell.



Working: -

 When light radiation falls on the P-n junction diode, electrons-hole pairs are generated by the absorption of the radiation.

 The electrons are drifted and collected at n-type end and the holes are drifted and collected at the P-type end.

 When these two ends are electrically connected through a conductor, there is a flow of current b/w the two ends through the external circuit. Thus, Photoelectric current is produced and available for use.

Advantages: -
 They are Environmental friendly.

 They need no recharging.

 They do not corrode.

 They operate at low temperature.

 No emission, no combustion.

 High public acceptance and excellent record.

 Low operating cost.

 No moving parts and so no wear and tear.

Disadvantages: -
 High installation cost.

 Energy can be produced only during the day time.

 Poor reliability of auxiliary elements including storage.

 Sun light is a diffuse, i.e., it is relatively low-density energy.

7) Explain the generation of hydrogen by alkaline water electrolysis.

ANS: Alkaline Water Electrolysis: -

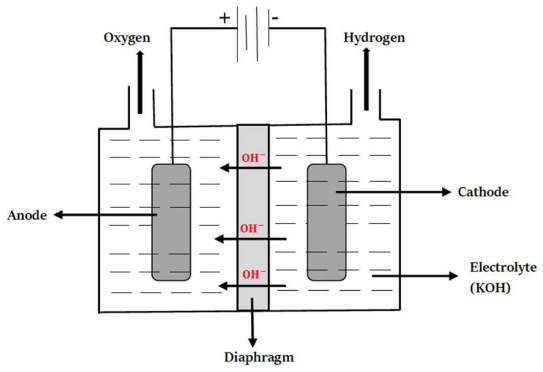
Construction: -
 It consists of two electrodes made from an inert metal such as platinum.

 The two electrodes are immersed in alkaline electrolyte solution like KOH with catalyst and connected to electrical power source.

 The electrodes are separated by using separator or diaphragm.

Working: -
 When current is supplied, hydroxide ions are formed at the cathode by the reduction of liquid water into gaseous hydrogen.

 The liberated hydroxyl ions migrate towards anode through diaphragm, where it was oxidized into oxygen and water.



Cathode Reaction: $2H_2O + 2e^- \longrightarrow H_2 + 2OH^-$

Anode Reaction: $2OH^- \longrightarrow 1/2\ O_2 + H_2O + 2e^-$

Net Reaction: $2H_2O \longrightarrow O_2 + 2H_2$

8) Explain the generation of hydrogen by proton exchange membrane water electrolysis.

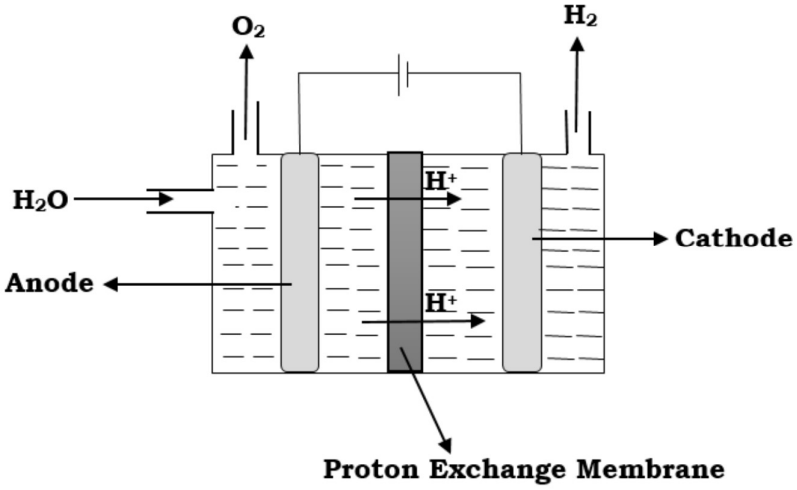
ANS:

Proton Exchange Water Electrolysis: -

It is an electrolysis of water in a cell equipped with a proton exchange membrane.

Construction: -

- It consists of anode electrode with iridium as catalyst.
- It consists of anode electrode with platinum as catalyst.
- It consists of proton exchange membrane between anode and cathode.



Working: -

- It is carried out by pumping of water to the anode, where it is split into oxygen (O_2), protons and electron.
- The liberated protons are moved to cathode through proton exchange membrane.
- In which proton and electrons combine to produce hydrogen (H_2).

Anode Reaction: $H_2O \longrightarrow 2H^+ + 1/2\ O_2 + 2e^-$

Cathode Reaction: $2H^+ + 2e^- \longrightarrow H_2$

Net Reaction: $H_2O \longrightarrow 2H^+ + 1/2\ O_2$

MODULE 5

1) What is an e-waste. Mention the sources, composition of e-waste.
ANS: Electronic waste describe unwanted rejected used and discarded electronic and electrical components, which causes environmental pollution.

Sources of E waste:

Any appliances that run on electricity has the potential to cause damage to the environment directly and indirectly. If it is not disposed properly.

1. Household appliances such as batteries, refrigerator televisions, washing machine dishwasher, bulbs, fluorescent lamps, switches, plugs, etc.
2. Information technology and telecommunication computer, laptop, mobile phone, printers, scanner & PCBS.

2) Explain the need for e-waste management.

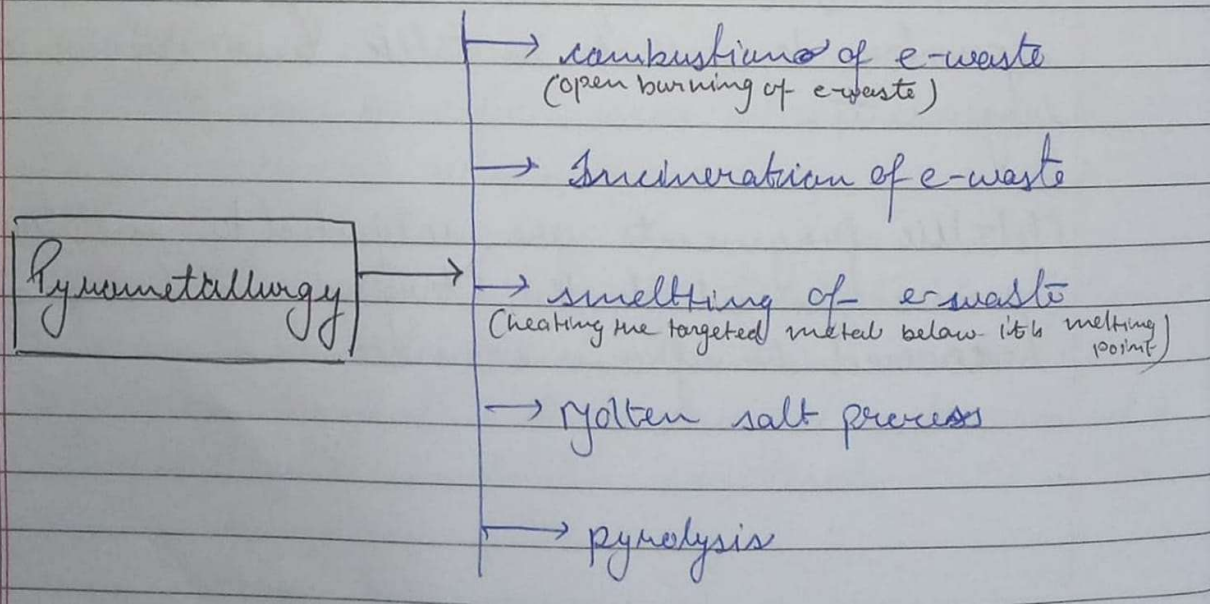
ANS: The need for e-waste management:
1. Reduces Hazardous chemicals.
2. Harmful effects on environment and ecosystem.
3. Decreases the emission of greenhouse gasses.
4. Protect the environment and ecosystem.
5. Reduce the cost of raw materials. (Demand and supply).

3) Explain the pyrometallurgical method for recycling of e-waste.
ANS:

i) Pyrometallurgy } Tutorial-2 Aug-10

It is the process of heating e-waste and its components below their melting points, and physical and chemical transformations are carried out to recover the valuable metals.

The following steps are used in Pyrometallurgy



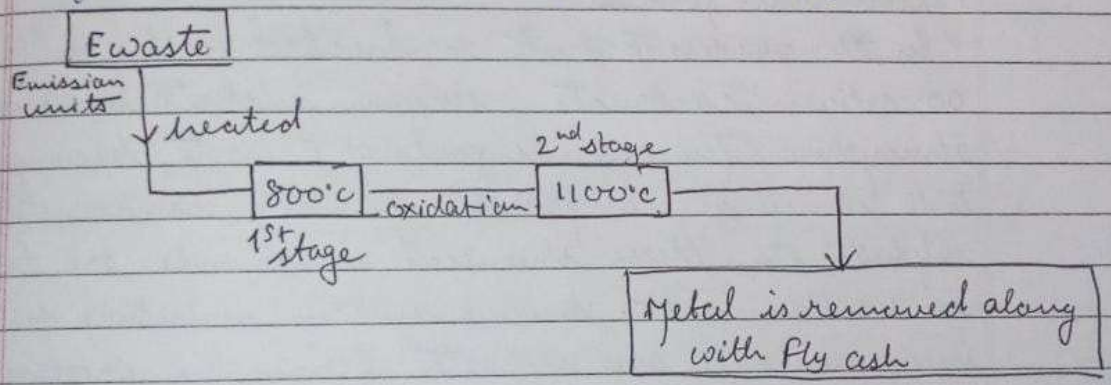
Combustion of E-waste

Combustion is low technology & low cost straight forward operation focussing only on the targeted metal.

E-waste is subjected to open burning in an uncontrolled manner which releases toxic gases into atmosphere hence this method is not advisable.

Incineration

Incineration is a process of heating E-waste in a scientific manner by using emission units. The targeted is obtained along with the fly ash.



Smelting

Smelting is a process of heating E-waste along with copper smelters. Copper smelting is commonly used for recovery of non-ferrous metals such as aluminium, palladium, chromium (Cr), Au, P

During smelting metals such as Al, Au, Pd, Cr are collected in a copper parent phase such as copper parent anode is further subjected to electrometallurgy from which the targeted metal is seperated from copper parent phase

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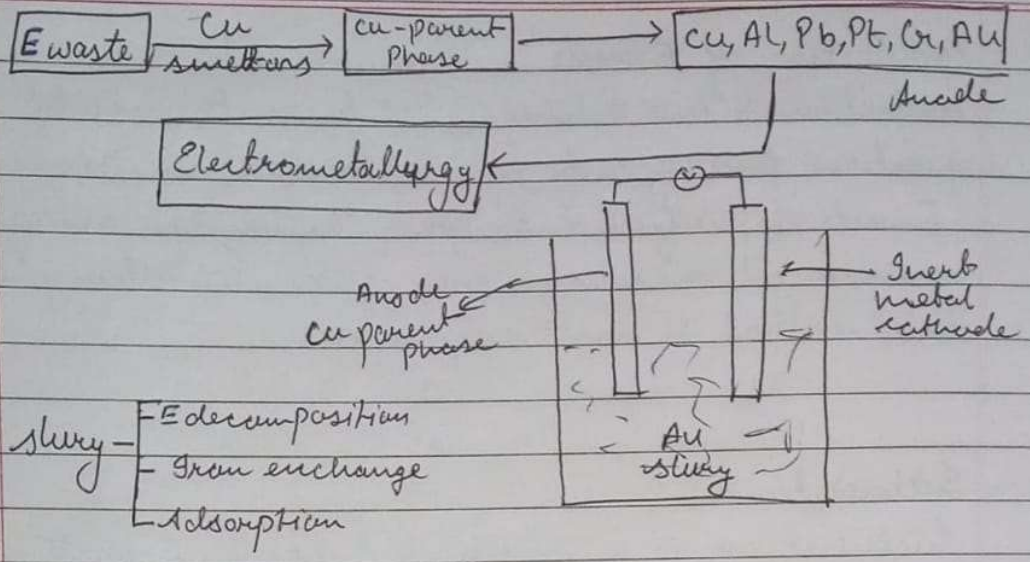
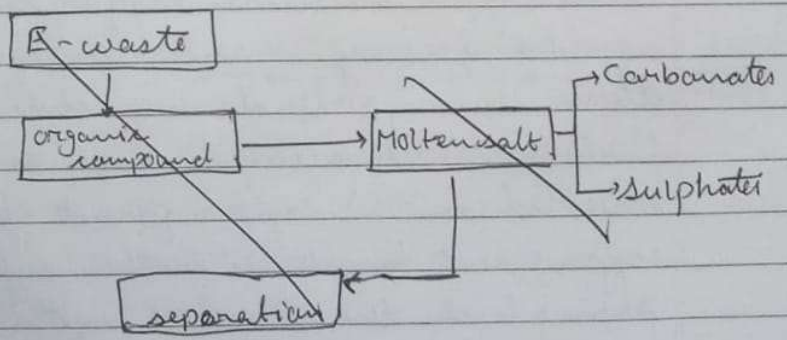
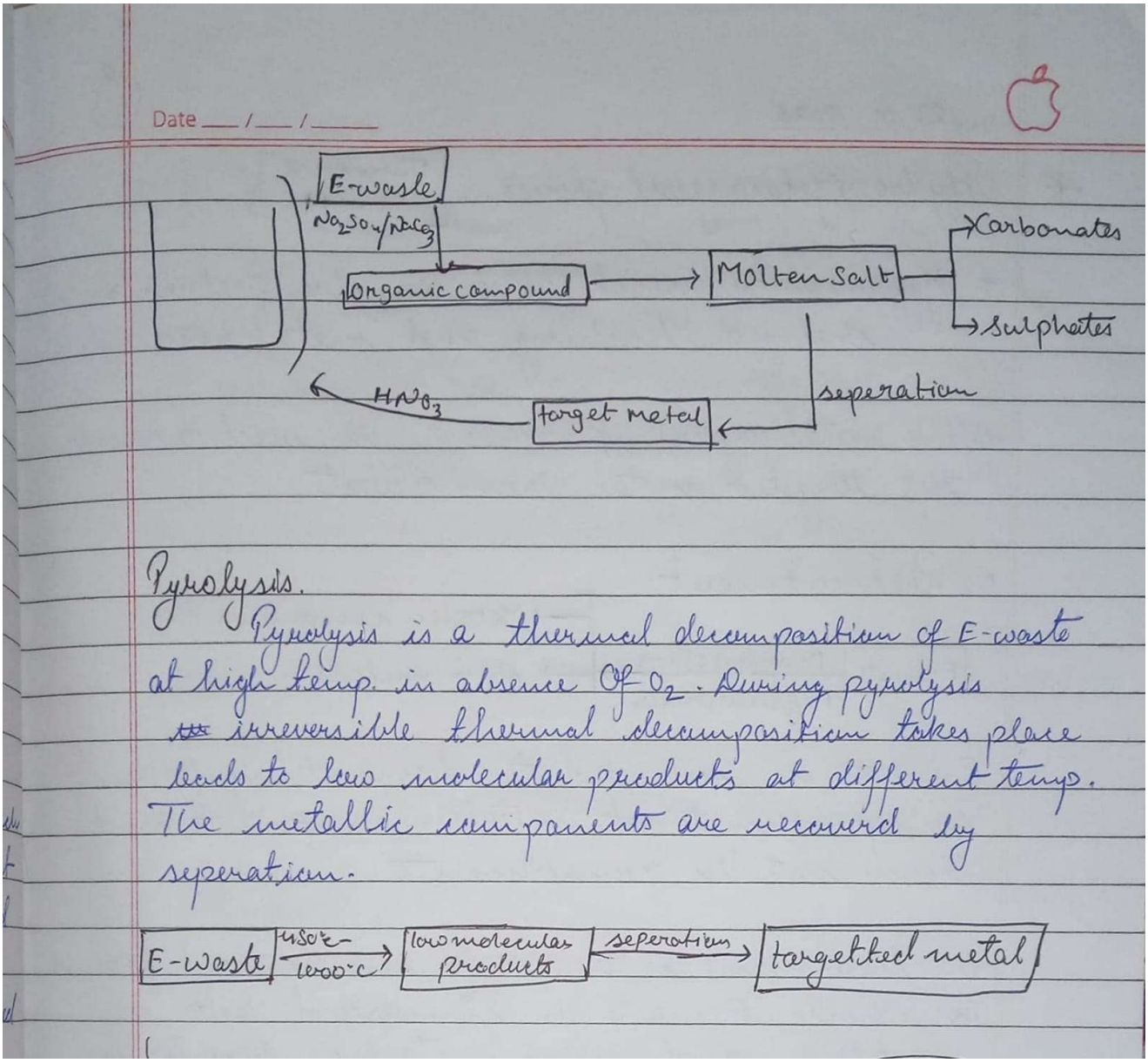


Molten salt process

In the process E-waste is heated with salt such as sodium carbonate, sodium sulphate in a inert atmosphere. The organic parts of E-waste decomposed into chemical compounds forming carbonates, sulphates etc., these chemical compounds are trapped in molten salt. Various molten mixture of inorganic salt are seperated from the process and the targeted metal is ~~recovered~~ recovered along with the fly ash.





4) Explain the Hydrometallurgical method for recycling of e-waste.

ANS:

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* Hydro Metallurgical process. [Tutorial-2 Ans#]

* Hydro metallurgical process involve pretreatment chemical leaching and metal recovery

Hydro metallurgical process is used to recover the targeted metal from e-waste

1. Pretreatment

E-waste → Dismantelling (Physical process) → Metalic components
→ Non metalic

E-waste is subjected to dismantling followed by seperation to get metallic components and non-metallic components

Pre-treatment is a purely mechanical process in which E-waste is converted into metallic and non-metallic fractions

2. Chemical leaching [chemical treatment]

~~Chemical leaching~~ or chemical treatm

Metallic components OF-E waste → Suitable Chemical → Leaching sol^{n}

Leaching is a process of dissolving metalling components by using suitable chemical agents.

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Ex→ Au component is leached with KCN (Alkali metal cyanide) under aerated condition.

Li components are leached with citric acid under aerated conditions

Pt components are leached with ammonium thio-sulphate

Chlorides and Bromides are also used to leach gold

3. Metal Recovery.

In this process the targeted metal is recovered by using these physical methods.

Metal recovery
- → ion exchange
- → Electro deposition
- → solvent extraction
- → Adsorption. (surface phenomena)

Ion exchange Method

Leached soln → (Poly mer resin) → targeted metal binds on resin → (selective Elution) → Metal

The leached soln containing targeted metal is passed into polymer ion exchange resin having functional groups, the metal ions selectively binds on a resin from which it is seperated.

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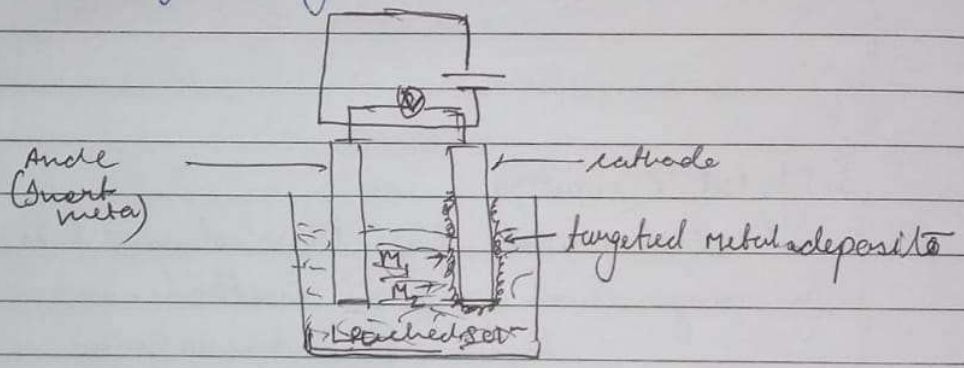
Advantages.

i) Low cost
ii) Easy to operate
iii) No loss of reagents
iv) Eco-friendly.

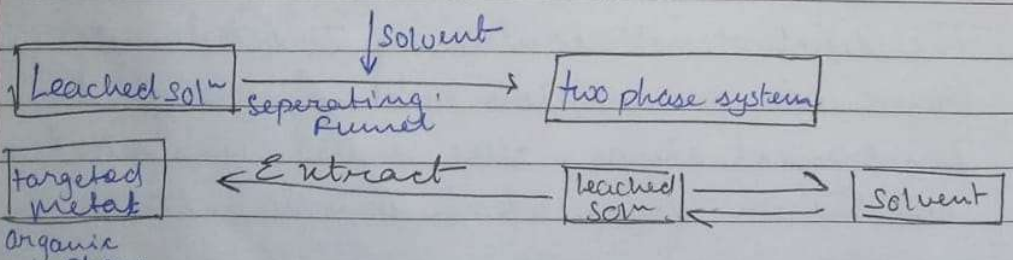
Electrodeposition.

It is the process of deposition of targeted metal on a cathode by using electrical ~~current~~ current.



Leached solution is electrode with inert anode and targeted metal cathode. When current is appy the targeted metal is deposited on a cathode (same type of metal cathode)

Solvent Extraction method.



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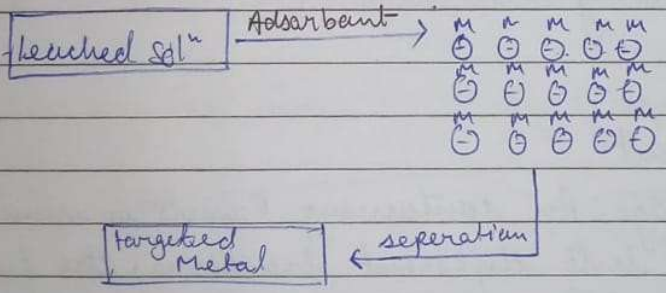
In this method the leached sol^{n} is treated with organic solvent, this leads to two phase system when extracts are added into a two phase system which extract the metal selectively in a organic phase

Ex:- Methyl-iso-butyl Ketone is used as a extractant for Au.

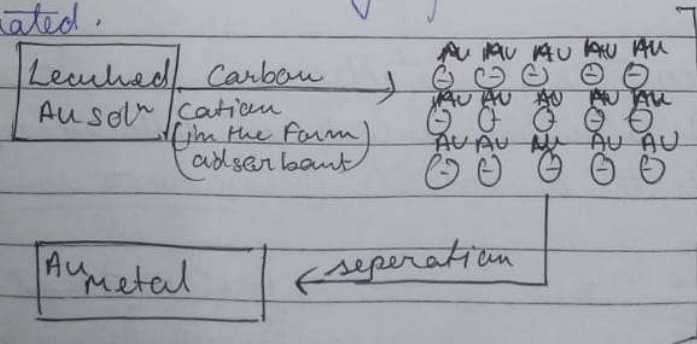
2. Amide extracts iridium
3 diamine extracts pt and Pd.

Adsorption.



Leached sol^{n} of a targetted metal is treated with suitable adsorbant, the metal gets adsorbed on adsorbant selectively from which it is seperated.

Ex:-



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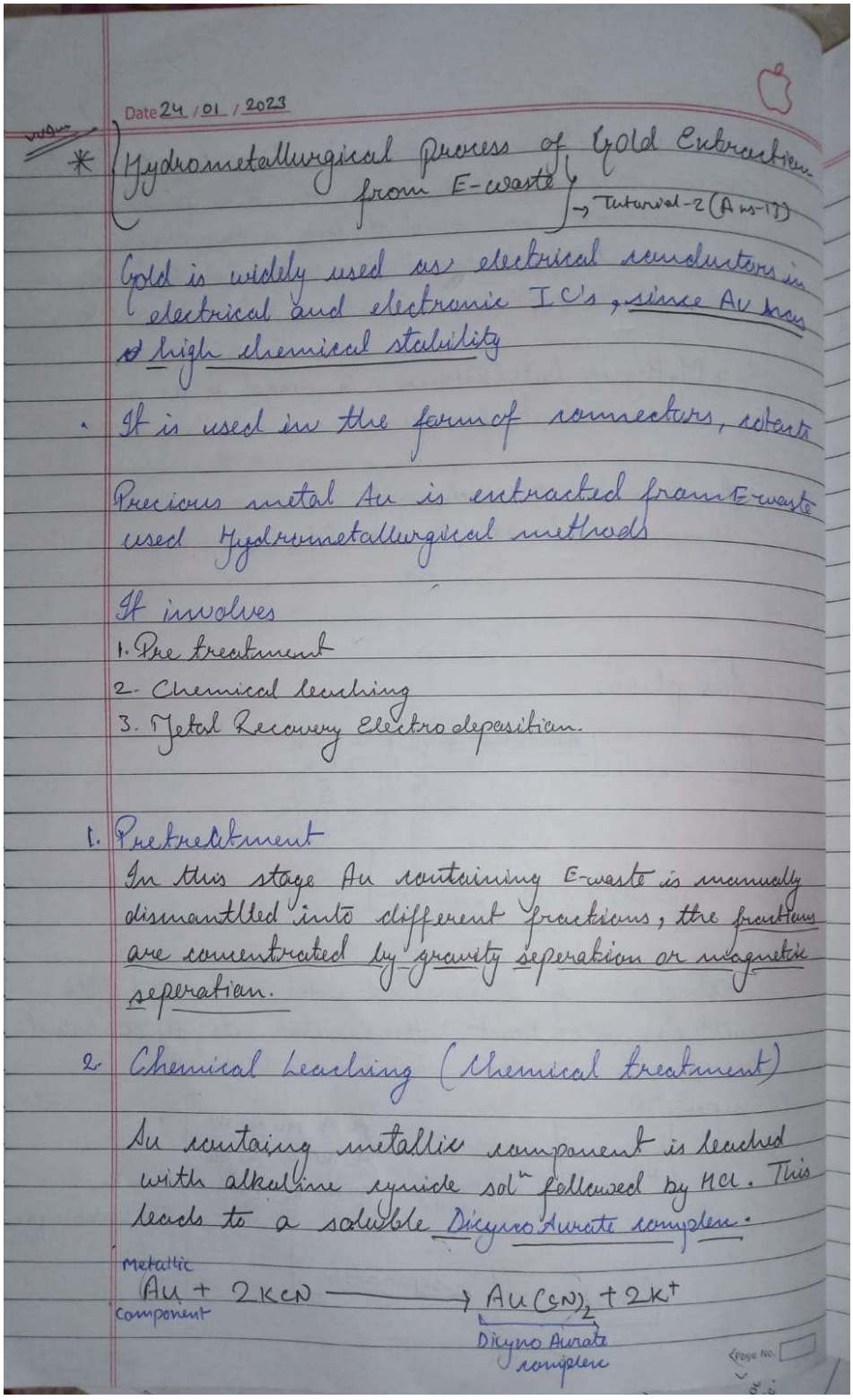
5) Explain the extraction of gold from e-waste.
ANS:



Date 24/01/2023

* Hydrometallurgical process of Gold Extraction from E-waste → Tutorial-2 (Ans-1)

Gold is widely used as electrical conductors in electrical and electronic IC's, since Au has high chemical stability

- It is used in the form of connectors, solders

Precious metal Au is extracted from E-waste used Hydrometallurgical methods

It involves
1. Pre treatment
2. Chemical leaching
3. Metal Recovery Electro deposition.

1. Pretreatment

In this stage Au containing E-waste is manually dismantled into different fractions, the fractions are concentrated by gravity seperation or magnetic seperation.

2. Chemical Leaching (Chemical treatment)

Au containg metallic component is leached with alkaline cyanide sol^n followed by HCl. This leads to a soluble Dicyano Aurate complex.

Metallic component

$$Au + 2KCN \longrightarrow \underbrace{Au(CN)_2}_{\text{Dicyno Aurate complex}} + 2K^+$$

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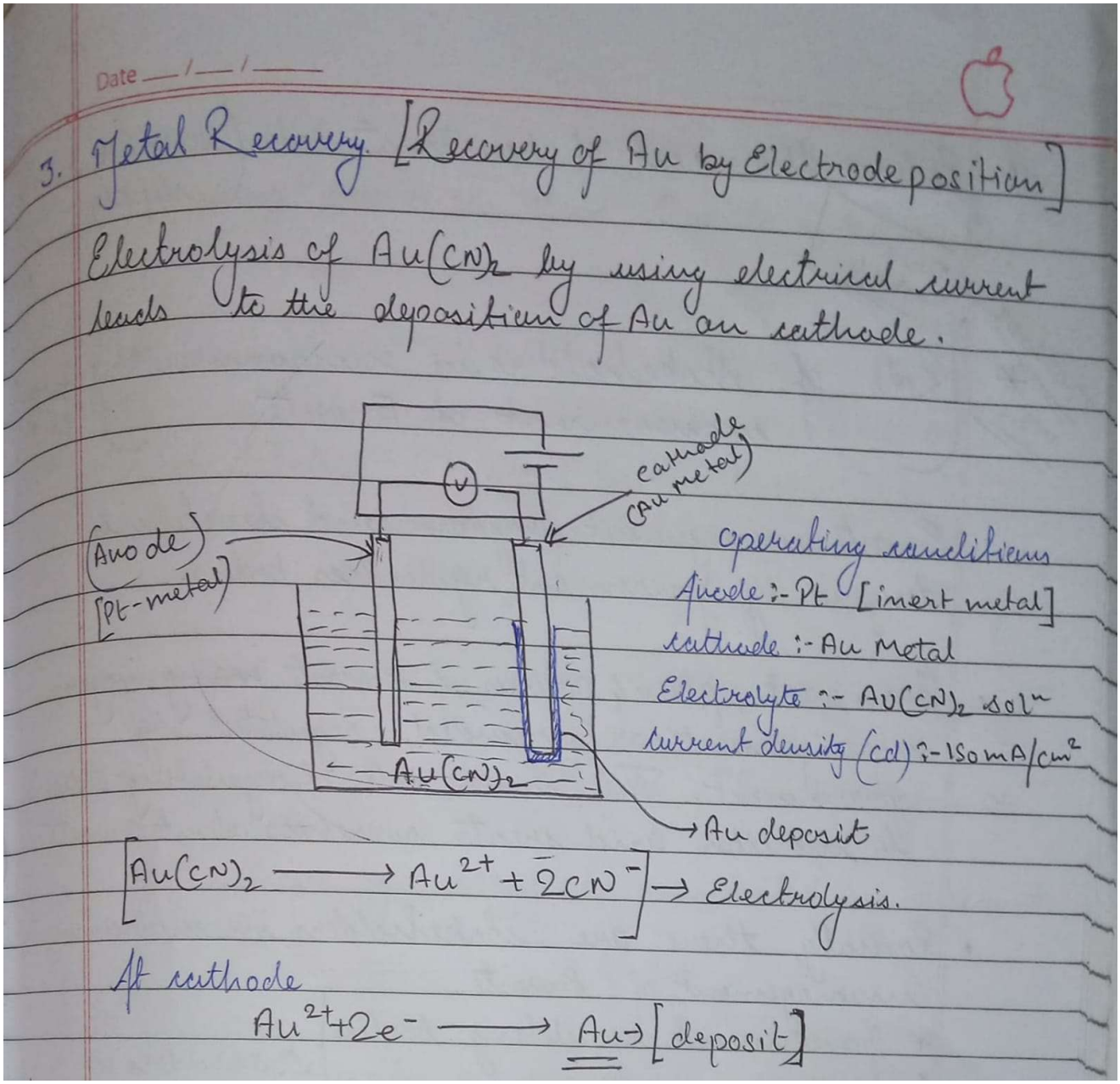

6) Write a brief note on role of stakeholders in environmental e- waste management in local perspective.

ANS:

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Role of Stakeholders in environmental management of E-waste

→ Factor id Any 14

- E-waste management program and structure is designed by Government regulatorities bodies.
- Framework, plans & policies of E-waste ~~mang~~ ~~mogem~~ management ar recomdtd, regulated by government. The main role of regulating bodies is to monitor and create awareness about E-waste
- Basically, there are stakeholders in environmental management of E-waste.
  * Government regulating bodies
  * Producers
  * Recycler
  * Consumers

  → Stakeholders in environmental management

* Govt. regulating bodies

The main role is

1. Collecting the green taxs from consumers through producers
2. Apply penalty to the producers in case of no proper disposal techniques.
3. ~~Provid~~ providing insentives, subsidies to recycler and collectors

Date __/__/____

4. Monitoring E-waste
5. Creating awareness about need of E-waste management.

* Producers

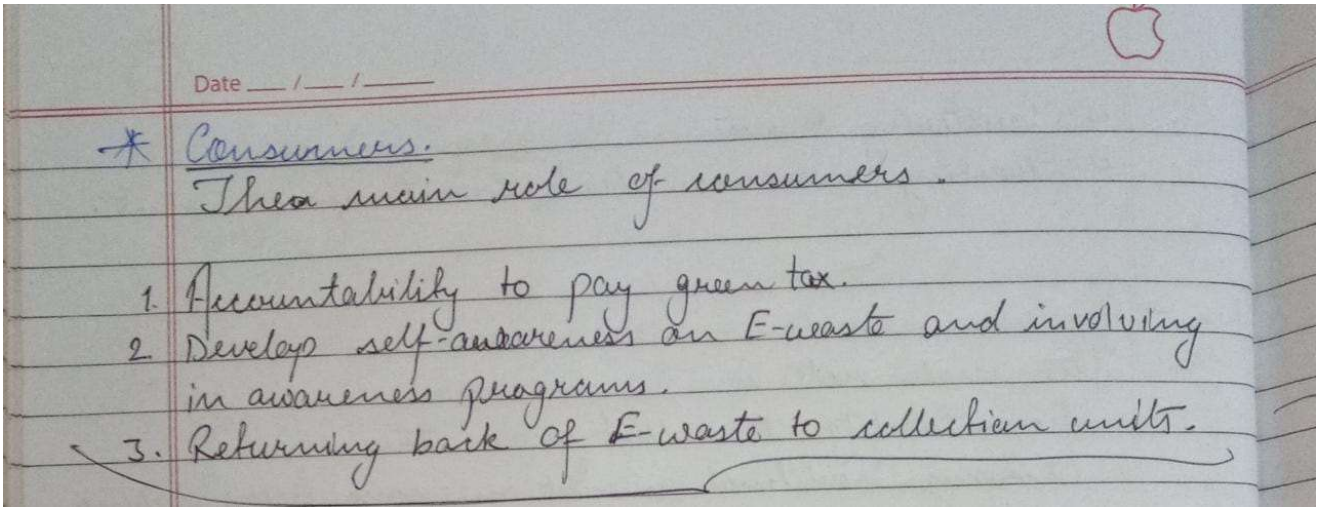
The main role is

1. Accountability to collect green tax
2. Charging additional amount on consumers during exchange or returning of components after use.
3. Forming clusters of manufacturers who monitor and encourage recycling of E-waste
4. Identification, collection & transportation of E-waste
5. Purchase of recycled, regenerated on discount basis

* Recyclers.

The main of recyclers in E-waste mang is

1. Accountability of recycling units. i.e, dismantling, recycling, reselling of regenerated components
2. Establish collection units and approaching consumers for door to door collection.
3. Collection of E-waste from collection units for
4. Providing insentives when proper collection of E-waste assured by collection units



7) Mention the Toxic materials used in manufacturing electronic and electrical products.

ANS: There are several toxic materials used in the manufacturing of electronic and electrical products. Here are some examples:

1. Lead: Lead has been widely used in the production of electronic products, especially in the soldering process. However, lead is highly toxic and can cause damage to the nervous system, brain, and other organs.

2. Mercury: Mercury is used in fluorescent lamps, switches, and other electronic components. It is a potent neurotoxin and can cause serious health problems, including brain and kidney damage.

3. Cadmium: Cadmium is used in batteries, coatings, and plastics. It can cause cancer, damage to the kidneys and lungs, and other health problems.

4. Chromium: Chromium is used in electronics for corrosion resistance and surface finishing. However, it can cause lung cancer, skin irritation, and other health problems.

5. Polyvinyl Chloride (PVC): PVC is a widely used plastic in electronic products. It contains harmful chemicals such as phthalates and dioxins, which can cause cancer and other health problems.

It is essential to properly dispose of electronic waste containing these toxic materials to prevent environmental and health hazards.

8) Briefly discuss health hazardous due to exposure to e-waste.

ANS: Exposure to e-waste can lead to several health hazards due to the presence of toxic materials such as lead, mercury, cadmium, and other harmful chemicals. Here are some of the health hazards associated with exposure to e-waste:

1. Respiratory problems: Inhalation of toxic fumes and dust from e-waste can cause respiratory problems such as asthma, bronchitis, and pneumonia.

2. Neurological problems: Exposure to lead and other toxic materials in e-waste can cause damage to the nervous system, leading to neurological problems such as seizures, memory loss, and developmental delays in children.

3. Cancer: Exposure to toxic materials such as cadmium and chromium can increase the risk of cancer, including lung, liver, and kidney cancer.

4.Reproductive problems: Exposure to e-waste can cause reproductive problems such as infertility, miscarriage, and birth defects.

5. Skin problems: Exposure to e-waste can cause skin irritation, rashes, and other skin problems.

To prevent these health hazards, it is essential to handle and dispose of e-waste properly, following environmental and health regulations. It is also important to recycle e-waste and reuse materials to reduce the amount of waste generated and minimize the exposure to harmful chemicals.