



LORDS INSTITUTE OF ENGINEERING TECHNOLOGY

UGC Autonomous

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Department of Science and Humanities

Academic Year: 2023-24

I-B.E. II-SEMESTER

QUESTION BANK

[SEE]

ENGINEERING CHEMISTRY

[U23CH201]

[Common for CSE, CSD, CE and MECH]

Prepared
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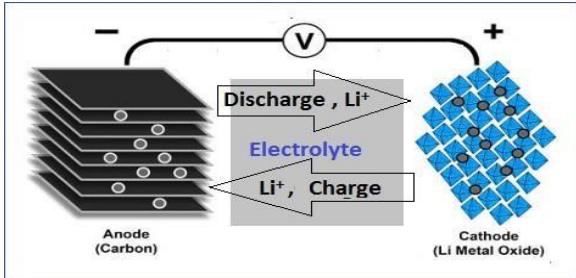
Note: A question bank is versatile and flexible FAQs that cover the entire syllabus of a subject. It is used by students and teachers for learning and assessment purposes only.



LORDS INSTITUTE OF ENGINEERING AND TECHNOLOGY
(UGC Autonomous)

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B.E –II SEMESTER,SEE QUESTIONBANK-2024
Engineering Chemistry
(Common To All Branches)

	<p style="text-align: center;">Lithium-Ion Battery(LIB)</p> <p>Lithium ion battery is a secondary battery. Lithium ion batteries are rechargeable batteries.</p>															
	<p>Construction</p> 	<p>The primary functional components of a Li-ion battery are,</p> <p>Anode(-ve): Porous Graphite</p> <p>Cathode (+ve): Lithium metal oxide ($\text{Li}_{1-x}\text{CoO}_2$)</p> <p>Electrolyte: A non-aqueous medium used as an electrolyte, usually which is a mixture of organic carbonate (ethylene carbonate) containing complex ($[\text{LiPF}_6]$) of lithium ions. Anode and cathode are separated by Electrical insulating separator (diaphragm) which permeable to lithium ions.</p>														
3.	Distinguish between electrolytic and electrochemical cells.	CO1 BTL2														
	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="background-color: #667380; color: white; text-align: center;">Electrolytic Cell</th><th style="background-color: #667380; color: white; text-align: center;">Galvanic cell</th></tr> </thead> <tbody> <tr> <td>Electrical energy (from an external source) is converted into chemical energy.</td><td>Chemical energy (of a redox reaction) is converted into electrical energy.</td></tr> <tr> <td>The electrodes may be made of same or different metals.</td><td>The electrodes are made of dissimilar metals.</td></tr> <tr> <td>At the electrodes, non-spontaneous reaction take place only when the electrical energy is supplied.</td><td>At the electrodes, spontaneous redox reaction take place.</td></tr> <tr> <td>Anode – Positive ; Cathode - Negative</td><td>Anode – Negative ; Cathode – Positive</td></tr> <tr> <td>Ions are discharged on both the electrodes</td><td>Ions are discharged only on the cathode.</td></tr> <tr> <td>Both electrodes are inserted in the same electrolytic solution.</td><td>Each electrode is dipped in electrolytic solution of its own ions.</td></tr> </tbody> </table>	Electrolytic Cell	Galvanic cell	Electrical energy (from an external source) is converted into chemical energy.	Chemical energy (of a redox reaction) is converted into electrical energy.	The electrodes may be made of same or different metals.	The electrodes are made of dissimilar metals.	At the electrodes, non-spontaneous reaction take place only when the electrical energy is supplied.	At the electrodes, spontaneous redox reaction take place.	Anode – Positive ; Cathode - Negative	Anode – Negative ; Cathode – Positive	Ions are discharged on both the electrodes	Ions are discharged only on the cathode.	Both electrodes are inserted in the same electrolytic solution.	Each electrode is dipped in electrolytic solution of its own ions.	
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Both electrodes are inserted in the same electrolytic solution.	Each electrode is dipped in electrolytic solution of its own ions.															
4.	What is a battery? Give an example?	CO1 BTL1														
	<p>Battery is a device consisting of one or more electrochemical cells connected parallelly or in series that converts stored chemical energy into electrical energy.</p>															

	<p>Primary batteries : Eg: Zinc– Carbon battery</p> <p>Secondary batteries</p> <p>Rechargeable batteries) : Eg: Lead- Acid battery ,Lithium ion battery.</p>		
5.	Calculate the electrode potential of $Zn Zn^{2+}$ electrode at $25^{\circ}C$. ($E^0_{Zn Zn^{2+}} = 0.76 V$)	CO1	BTL2
6.	Calculate the electrode potential of $Zn^{2+} Zn$ electrode at $25^{\circ}C$. ($E^0_{Zn^{2+} Zn} = -0.76 V$)	CO1	BTL2
7.	Represent the Calomel electrode and writes its electrode reaction.	CO1	BTL2
	<p>Calomel electrode is represented as $Pt-Hg/Hg_2Cl_2/KCl(aq)$.</p> <div style="background-color: #e0e0ff; padding: 10px; border-radius: 10px;"> <p>When it acts an cathode</p> $Hg_2^{2+} + 2e^- \longrightarrow 2Hg$ $Hg_2Cl_2 \longrightarrow Hg_2^{2+} + 2Cl^-$ </div> <div style="background-color: #d0e0ff; padding: 10px; border-radius: 10px;"> <p>When it acts an anode</p> $2Hg \longrightarrow Hg_2^{2+} + 2e^-$ $Hg_2^{2+} + 2Cl^- \longrightarrow Hg_2Cl_2$ </div> <div style="background-color: #ffffcc; padding: 10px; border-radius: 10px;"> <p>The net reversible reaction is:</p> $Hg_2Cl_2 + 2e^- \longleftrightarrow Hg_2^{2+} + 2Cl^-$ </div>		
8.	<p>Find the EMF of the following cell</p> $Zn / Zn^{2+}(1 M) // Cu^{2+}(1M) / Cu$ given $E^0(Zn Zn^{2+}) = 0.76 V$ & $E^0(Cu^{2+} Cu) = 0.34 V$	CO1	BTL2
9.	Calculate the electrode potential of copper electrode at $25^{\circ}C$, if $CuSO_4 = 0.001 M$ and $E^0(Cu^{2+} Cu) = 0.34 V$	CO1	BTL2
10.	Define single and standard electrode potentials.	CO1	BTL1
	<p>Single Electrodepotential:</p> <p><i>Tendency of an electrode to lose or gain electrons when it is in contact with its own ionic solution is called as electrode potential.</i></p> <p><i>The tendency of an electrode to lose electrons i.e.to get oxidised, is called Oxidation potential,where as,the tendency of an electrode to gain electrons i.e.to get reduced,is called Reduction potential.</i></p> <p>Standardelectrodepotential:</p> <p>The potential of an electrode, at a given temperature, depends upon the concentration of solution of its ions.</p> <p><i>"The tendency of a pure metal or pure gas at 1 atm pressure to undergo oxidation or reduction when it is in contact with 1M</i></p>		

	solution of its ions at 25°C , is called as standard electrode potential.														
11.	Mention two half-cell reactions of methanol – oxygen fuel cell.	CO1	BTL2												
	Electrode reactions:														
	Anode	$\text{CH}_3\text{OH} + \text{H}_2\text{O} \rightarrow \text{CO}_2 + 6\text{H}^+ + 6\text{e}^-$													
	Cathode	$\frac{3}{2} \text{O}_2 + 6\text{H}^+ + 6\text{e}^- \rightarrow 3 \text{H}_2\text{O}$													
	Overall	$\text{CH}_3\text{OH} + \frac{3}{2} \text{O}_2 \rightarrow \text{CO}_2 + 2 \text{H}_2\text{O}$													
12.	What is galvanic cell? Write its anodic and cathodic reactions.	CO1	BTL2												
	<p>GALVANIC CELL A device in which chemical energy is changed to electrical energy.</p> <table border="1"> <tr> <td>Oxidation half-reaction $\text{Zn(s)} \rightarrow \text{Zn}^{2+}(\text{aq}) + 2\text{e}^-$</td> <td></td> </tr> <tr> <td>Reduction half-reaction $2\text{e}^- + \text{Cu}^{2+}(\text{aq}) \rightarrow \text{Cu(s)}$</td> <td></td> </tr> <tr> <td>Overall (cell) reaction $\text{Zn(s)} + \text{Cu}^{2+}(\text{aq}) \rightarrow \text{Zn}^{2+}(\text{aq}) + \text{Cu(s)}$</td> <td></td> </tr> </table>			Oxidation half-reaction $\text{Zn(s)} \rightarrow \text{Zn}^{2+}(\text{aq}) + 2\text{e}^-$		Reduction half-reaction $2\text{e}^- + \text{Cu}^{2+}(\text{aq}) \rightarrow \text{Cu(s)}$		Overall (cell) reaction $\text{Zn(s)} + \text{Cu}^{2+}(\text{aq}) \rightarrow \text{Zn}^{2+}(\text{aq}) + \text{Cu(s)}$							
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13.	Differentiate reversible cell from irreversible cells?	CO1	BTL2												
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14.	Write half-cell and complete cell reaction for given cell notation. $\text{Zn/Zn}^{+2} // \text{Ag}^+/\text{Ag}$	CO1	BTL2												
15.	Write a note on Glass electrode.	CO1	BTL1												

- A glass electrode is made of a long glass tube with a thin walled glass membrane bulb at the bottom.
- A Pt wire or AgCl coated Ag wire is dipped in the 0.1 M HCl solution in the bulb.

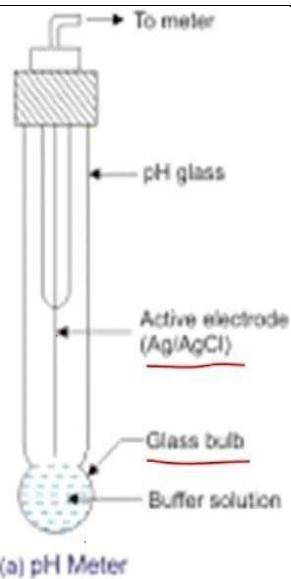


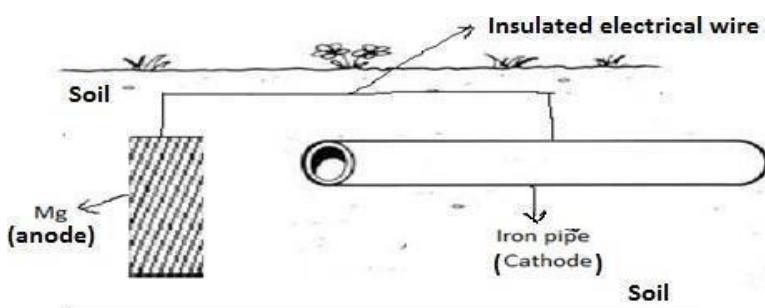
Fig: Glass Electrode

The representation of glass electrode is, $\text{Ag}/\text{AgCl}/0.1\text{N HCl}/\text{Glass membrane}$. The potential of the glass electrode is given as, $E_G = E^0 - 0.0591 \frac{pH}{G}$

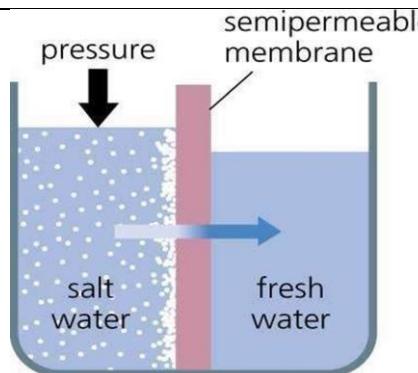
UNIT- II WATER CHEMISTRY AND CORROSION

16.	Explain sacrificial anodic method of protecting corrosion.	CO2	BTL2
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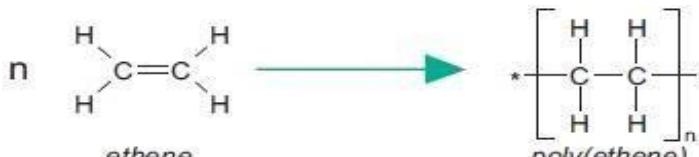
In this method, the metallic structure to be protected is electrically connected to a more active or anodic metal than the metallic structure to be protected. The more active metal acts as anode and gets corroded slowly; while the parent structure (metallic structure to be protected) is forced to act as cathode of galvanic cell, hence protected. As this more active metal is sacrificed its life in the process of saving metallic structure from corrosion, it is known as sacrificial anode and, therefore, this method is called as sacrificial anodic protection



17.	What are the specifications of potable water.	CO2	BTL1
	<p>Specifications of Potable water/Drinking/Municipal water (any four)</p> <p>Water which safe to drink is said to be potable water or drinking water. Potable water should have following specifications,</p> <ol style="list-style-type: none"> 1. Should be sparkling clear and odorless 2. Water should be pleasant in taste. 3. Water should be perfectly cool and its turbidity should not exceed 10 ppm. 4. It should be free of objectionable minerals such as lead, arsenic, chromium and manganese salts. 5. pH should be around 8 6. Dissolved salts should be less than 500 ppm 7. It should be free from disease-producing microorganisms. 8. Chloride, Fluoride & Sulphate contents should be less than 250 ppm, 1.5 ppm and 250 ppm respectively 		
18.	How does Zinc protect the Iron from corrosion?	CO2	BTL2
	<p>Galvanising is a method of rust prevention. The iron or steel object is coated in a thin layer of zinc. This stops oxygen and water reaching the metal underneath – but the zinc also acts as a sacrificial metal. Zinc is more reactive than iron, so it oxidises rather than the iron object.</p>		
19.	A sample of water gives an analysis 13.6 mg/L of CaSO_4 , 7.3 mg/L of $\text{Mg}(\text{HCO}_3)_2$. Calculate the total hardness and permanent hardness.	CO2	BTL 2
20.	Define the term “Reverse osmosis”.	CO2	BTL1
	<p>REVERSE OSMOSIS: When two solutions of unequal concentration are separated by a semi-permeable membrane, flow of solvent takes place from dilute to concentration side, due to increase in osmotic pressure, which is termed as osmosis. However, when a hydrostatic pressure in excess of osmotic pressure is applied on the concentrated side, the solvent flow is reversed from concentrated side to dilute side, across the membrane. This principle is termed as reverse osmosis</p>		



21.	A Sample of hard water contains the following dissolved salts per litre. $\text{CaCl}_2 = 111 \text{ mgs}$, $\text{CaSO}_4 = 1.36 \text{ mgs}$, $\text{Ca}(\text{HCO}_3)_2 = 16.2 \text{ mgs}$, $\text{Mg}(\text{HCO}_3)_2 = 14.6 \text{ mgs}$, Silica = 40 gms, Turbidity = 10 mgs. Calculate the temporary, permanent and total hardness of water in ppm	CO2	BTL 2
22.	Explain the significance of Break Point Chlorination.	CO3	BTL1
	<p>Significanc: Involves in addition of sufficient amt. of chlorine to oxidise :organic matter, reducing substances.</p> <p>Dosage of applied chlorine to water rich inorganic compound or ammonia is gradually increased.</p> <p>All tastes, odour disappear at breakpoint</p> <p>water free from bad tastes and odours</p>		
23.	Explain the principle of cathodic protection.	CO3	BTL2
	<p>Cathodic protection:</p> <p>The principle involved in this method is to force the metal to be protected (Parent metal) to behave like cathode. Therefore, corrosion of the parent metal is prevented.</p> <p>There are two types of cathodic protections,</p> <p>(a)Sacrificial anodic protection (b)Impressed current cathodic protection.</p>		
24.	When copper is in contact with Iron what will be corroded and why?	CO3	BTL2
	<p>When copper comes in contact with iron, it makes the process of rusting faster.</p> <p>This is because copper has higher reduction potential than iron, and makes the oxidation of iron faster hence rusting</p>		
25.	50 ml of sample water consumed 20 ml of EDTA before boiling and 5 ml of the same EDTA after boiling. Calculate the total, permanent and temporary hardness.	CO2	BTL3
26	What is hardness of water? Write its unit.	CO3	BTL2
	<p>Hardness of Water: Hardness of water is “the characteristic that prevents lathering of soap”.(Or)It is defined as“ the soap consuming capacity of</p>		

	<p>reducing substances. Dosage of applied chlorine to water rich inorganic compound or ammonia is gradually increased. All tastes, odour disappear at breakpoint water free from bad tastes and odours</p>		
30.	Calculate the total hardness of 1000 litre of a water sample containing the following impurities: 16.2 mg/L - Ca(HCO ₃) ₂ , 11.1 mg/L - CaCl ₂ , 60 mg/L - MgSO ₄ & 19 mg/L - MgCl ₂	CO2	BTL 3
UNIT: III ENGINEERIN GMATERIALS			
31.	What is Polymer? Give an example.	CO4	BTL1
<p>Polymers are high molecular weight giant molecules formed by linking together of small molecules, monomers, by means of covalent bond/chemical bond. Examples: poly ethylene, poly (vinyl chloride), Bakelite, etc.</p> 			
32.	Define degree of polymerization.	CO4	BTL1
<p>Number of monomers/repeat units present in the polymer is called “Degree of polymerization”. Example</p> $100 \text{ CH}_2=\text{CH}_2 \xrightarrow{\text{Polymerization}} -\text{-(CH}_2-\text{CH}_2\text{)}_{100}-$ <p style="text-align: center;">DP=100</p>			
33.	Write the properties and applications of PVC .	CO4	BTL2
<p>Properties Rigid PVC is a colourless, odourless and non-inflammable. 2. It has excellent oil resistance and resistance to weathering.</p> <p>Applications</p> <ol style="list-style-type: none"> 1. Leather cloth used for car seat, covers etc 2. Kitchen upholstery, ladies hand bags, plastic rain coats 3. Baby pants, swim suits etc. 			
34.	Distinguish between addition polymerization from condensation polymerization	CO4	BTL2

Addition polymerization/Chain growth polymerization:

- ✓ Addition polymerization is a reaction that yields a polymer which is an exact multiple of monomers, without the elimination of by-products.
- ✓ Monomers having double bonds such as alkenes, alkynes, undergo addition polymerization.

Condensation polymerization/step polymerization:

- ✓ Condensation polymerization is a reaction occurring between two bi – or poly functional monomers having polar functional groups.
- ✓ It always accompanies with elimination of small molecules like H_2O , HCl , NH_3 , etc.
- ✓ For example, $>\text{C=O}$, $-\text{COOH}$, $-\text{OH}$ and $-\text{NH}_2$ carrying monomers undergo condensation polymerization.

35.	Distinguish between homo polymer and co – polymer.	CO4	BTL2
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Homo polymers: The polymers which are made up of identical monomer units are called as homo polymer.

....–M–M–M–M–M–M–.....

Examples: polythene, polystyrene, poly (vinyl chloride), etc.

- ✓ **Co-polymers:** The polymers which are made up of different monomers are known as co-polymers.

Examples: Buna-S, etc.

36.	What is the requirement for a simple organic compound to function as a monomer?	CO4	BTL2
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The small molecules to act as a monomer, their functionality should be at least two

it must have **at least one double bond** or functional groups

37.	Define monomer and its functionality.		
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Monomers: The small individual molecules which combine with each other to form large molecules are called monomers.

Examples: Ethylene, vinyl chloride, styrene, etc.

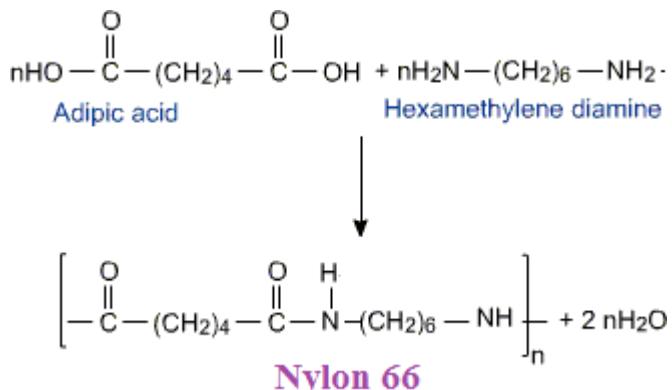
Functionality of Monomer: “The Number of bonding sites present in a monomer” is called functionality of monomer

Name of Mono mer	Structure	Functiona lity
Ethene	$\text{CH}_2=\text{CH}_2$	2
1,3-butadiene	$\text{CH}_2=\text{CH}-\text{CH}=\text{CH}_2$	2

38.	What is conducting polymer? Give one example.	CO4	BTL2
	The polymers which can conduct electricity due to extensive conjugation are called as conducting /conductive polymers.		
	<p>Examples:</p> <p><i>trans</i>-polyacetylene: A repeating unit consisting of two ethylene groups connected by a single bond, with a subscript 'x' indicating the polymer chain.</p> <p>polypyrrole: A repeating unit consisting of a pyrrole ring with a nitrogen atom, where the nitrogen is bonded to a hydrogen atom, with a subscript 'x' indicating the polymer chain.</p> <p>polythiophene: A repeating unit consisting of a thiophene ring with a sulfur atom, with a subscript 'x' indicating the polymer chain.</p> <p>Polyaniline: A repeating unit consisting of a linear chain of four benzene rings linked by amine (-NH-) and imine (=N-) groups, with a subscript 'n' indicating the polymer chain.</p>		
39.	Explain the applications of conducting polymers.	CO4	BTL2
	<p>List down applications(any four)</p> <ul style="list-style-type: none"> • It is used in photo voltaic devices. • It is used as non linear optical material • It is used in Transistors Light Emitting Diodes (LEDs) • Lasers used in flat televisions • Solar cells • Electro chromic displays and optical filters • In electronics • In rechargeable batteries • Displays in mobile telephones and mini-format television screens • anti-static substances for photographic film • Corrosion Inhibitors • Compact Capacitors • Anti Static Coating Electromagnetic shielding for computers "Smart Windows" 		
40.	Write a note on bio- degradable polymers.	CO4	BTL1
	<p>Biodegradable polymers are defined as “the polymeric materials that undergo degradation by environmental factors like sunlight, temperature changes or by the action of micro organisms like algae, fungi and bacteria” Example: Polylactic acid.</p> <p>the advantages of Biodegradable polymer.</p> <ul style="list-style-type: none"> • <i>They are easily compostable.</i> • <i>It is used to produce non toxic products</i> • <i>It is capable of maintaining good mechanical integrity until degradation</i> • <i>It is used for packing ,agriculture, and medicine</i> 		
41.	Give the synthesis of Nylon 6,6	CO4	BTL2
	Nylon 66:		

Preparation: It is prepared by the condensation polymerization of adipic acid with hexamethylene diamine.

Properties:



42.	Write a note on properties and application of Kevlar	CO4	BTL2
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Properties:

- It is very rigid polymer
- Exceptionally strong (Five times stronger than steel and 10 times stronger than Al) and has high heat stability.
- The unique properties of Kevlar are due to the benzene rings which are linked to the amide group. There are stronger inter molecular forces between neighboring chains, which make it exceptionally strong.

Uses:

- Used in tyres, brakes, clutch lining and other car parts.
- Bullet-proof vests.
- Motor cycle helmets.
- Used in Aerospace and air-craft industries.

43.	Write a note on properties and application of BUNA S	CO4	BTL2
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Properties: Buna-S has the following properties,

- High abrasion resistance and load bearing capacity.
- Good Resilience.
- It swells in oils and solvents.
- It gets readily oxidized due to the presence of unsaturation.

Uses: SBR is used for making,

- Automobile tyres, foot wear components.
- Insulation for electrical wires.
- Conveyor belt, tank lining.

44.	Write a short note on Doping.	CO4	BTL2
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Doping is “addition of impurities or creation of positive or negative charge.

The conducting polymers with high conjugation can be easily oxidised or reduced as they have low ionisation potential. Their conductivities can be increased by creating positive or negative charge on polymer backbone by oxidation or reduction.

Doping is two types: P-Doping (Oxidative doping) & N-Doping (Reductive doping)

45.	Write a applications of poly lactic acid	CO4	BTL 1
	<p>Applications of poly lactic acid (ANY FOUR)</p> <p>Packaging: PLA is used in food packaging, disposable cups, cutlery, and containers due to its biodegradability and compatibility with food.</p> <p>Medical Devices: It's used in medical implants, sutures, and drug delivery systems due to its biocompatibility and ability to degrade in the body.</p> <p>3D Printing: PLA is popular in 3D printing due to its ease of use, biodegradability, and ability to produce intricate designs.</p> <p>Textiles: It's used in making textiles and clothing, providing a sustainable alternative to traditional synthetic fibers.</p> <p>Biomedical Engineering: PLA is employed in tissue engineering, creating scaffolds for tissue regeneration and wound healing.</p> <p>Films and Coatings: It's used to make biodegradable films for packaging, agricultural films, and coatings for paper.</p>		
	UNIT: IV CHEMICAL FUELS		
46.	Classify fuels with suitable examples.	CO5	BTL2
	<pre> graph TD A[Classifications of Fuels] --> B[Based on occurrence] A --> C[Based on Physical State] B --> D["Primary or natural fuels (e.g., wood, coal)"] B --> E["Secondary or artificial fuels (E.g Charcoal, Coke)"] C --> F["Solid fuel (e.g., wood, coal)"] C --> G["Liquid fuels (E.g. Crude petroleum)"] C --> H["Gaseous fuel (e.g., natural gas)"] </pre>		
47.	Define LCV of a fuel.	CO5	BTL1
	<p>Lower calorific value or Net calorific value: It is defined as “the net heat produced, when unit mass or unit volume of the fuel is burnt completely and the combustion products are allowed to escape.</p> <p>Net calorific value = Gross calorific value – Latent heat of water vapors formed LCV or NCV= HCV – Latent heat of water vapour formed</p> $LCV = HCV - \frac{9H}{100} \times 587 \text{ cal/g} \quad (\text{Latent heat of steam is } 587 \text{ cal/g.})$ <p>Where, H is the percentage of hydrogen. NCV = GCV – 0.09H × 587 kcal/kg</p>		

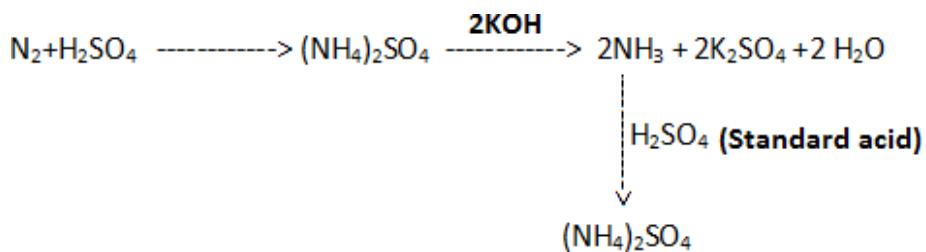
48.	Explain determination of moisture content in coal.	CO5	BTL1
	<p>Determination of moisture content in coal</p> <p>About 1 gm of powdered, air dried coal sample is heated in silica crucible at 100 to 105 °C for one hour. Percentage of moisture can be calculated from the loss in weight of the coal sample as</p> $\therefore \% \text{ of moisture in coal} = \frac{\text{Loss in weight of coal}}{\text{Weight of coal initially taken}} \times 100$		
49.	Define HCV of a fuel.	CO5	BTL1
	<p>Higher calorific value or Gross calorific value: It is defined as the total amount of heat liberated; when unit mass or unit volume of the fuel has been burnt completely and the products of combustion are cooled down to room temperature. Measured heat includes latent heat of water vapour produced.</p> $\text{HCV (or) GCV} = 1/100 (8080 C + 34500 (H - O/8) + 2240 S) \text{ Cal/g or Kcal/kg}$		
50.	List down significance of proximate analysis.	CO5	BTL1
	<p>Significance (or) Importance of Proximate Analysis :</p> <p>MOISTURE: Moisture High moisture content in coal is undesirable because it, i) Reduces Calorific Value of coal Hence, lesser the moisture content, better is the quality of coal.</p> <p>VOLATILE MATTER: The coal with higher volatile content, Has lower Calorific Value Will give more quantity of coal gas when it is heated in absence of air.</p> <p>ASH: High ash content in coal is undesirable because it (a) increases transporting, handling, storage costs, (b) is harder and stronger, (c) has lower Calorific Value.</p> <p>FIXED CARBON: Fixed Carbon It is the pure carbon present in coal. Higher the fixed carbon content of the coal, higher will be its Calorific Value</p>		
51.	What are the requirements of good fuel?	CO5	BTL2
	A good fuel should satisfy the following requirements:		

	<p>It should have a high calorific value.</p> <p>An ideal fuel should have moderate ignition temperature.</p> <p>Its moisture content should be low.</p> <p>Low volatile matter content.</p> <p>It should not produce harmful products like CO_2, SO_2, H_2S and other poisonous gases on combustion since they pollute the atmosphere.</p> <p>A fuel should have low content of non-combustible matter.</p> <p>It should be economical and easily available.</p>	
52.	Write the advantages of gaseous fuels.	CO5 BTL2
	<p>Advantages of gaseous fuels:</p> <ol style="list-style-type: none"> 1. Gaseous fuels can be easily transported through the pipes. 2. They do not produce any ash or smoke during burning. 3. They have high calorific value than the solid fuels. 4. They have high thermal efficiency. 	
53.	Distinguish between Gross and Net calorific value of a fuel.	CO5 BTL2
	<p>Higher calorific value or Gross calorific value: It is defined as the total amount of heat liberated; when unit mass or unit volume of the fuel has been burnt completely and the products of combustion are cooled down to room temperature. Measured heat includes latent heat of water vapour produced.</p> <p>HCV (or) GCV = $1/100 (8080 C + 34500 (H - O/8) + 2240 S)$ Cal/g or Kcal/kg</p> <p>Lower calorific value or Net calorific value: It is defined as the net heat produced, when unit mass or unit volume of the fuel is burnt completely and the combustion products are allowed to escape.</p> <p>Net calorific value = Gross calorific value – Latent heat of water vapour formed LCV or NCV = HCV – Latent heat of water vapour formed</p> <p>$\text{LCV} = \text{HCV} - \frac{9H}{100} \times 587 \text{ cal/g} \quad (\text{Latent heat of steam is } 587 \text{ cal/g.})$</p> <p>Where, H is the percentage of hydrogen.</p> <p>$\text{NCV} = \text{GCV} - 0.09H \times 587 \text{ kcal/kg}$</p>	

54.	Give Dulong's formula and relate HCV to LCV.	CO5	BTL2
	<p>Higher calorific value or Gross calorific value: $HCV \text{ (or) } GCV = 1/100 (8080 C + 34500 (H - O/8) + 2240 S) \text{ Cal/g or Kcal/kg}$</p> <p>Lower calorific value or Net calorific value:</p> <p style="margin-left: 40px;">Net calorific value = Gross calorific value – Latent heat of water vapour formed LCV or NCV = HCV – Latent heat of water vapour formed</p> $LCV = HCV - \frac{9H}{100} \times 587 \text{ cal/g} \quad (\text{Latent heat of steam is } 587 \text{ cal/g.})$ <p>Where, H is the percentage of hydrogen. $NCV = GCV - 0.09H \times 587 \text{ kcal/kg}$</p>		
55.	What is the effect of hydrogen and oxygen on the calorific value of fuel?	CO5	BTL2
	<p>Hydrogen :</p> <p>Higher the % of carbon and hydrogen, better the quality of coal and higher is its calorific value.</p> <p>Oxygen</p> <ol style="list-style-type: none"> 1. Lower the % of oxygen higher is its calorific value. 2. As the oxygen content increases its moisture holding capacity increases and the calorific value of the fuel is required.. 		
56.	A sample of coal has the following composition by mass Carbon 75 %, Hydrogen 6%, Oxygen 8%, Nitrogen 2.5 %, and Ash 7 %. Calculate the higher calorific value of a coal.	CO5	BTL2
57.	Write the composition of Liquid petroleum gas.	CO5	BTL1
	<p>It is obtained as one of the top fractions in the fractional distillation of petroleum.</p> <p>Composition Its approximate composition is</p> <p>n-Butane = 70 %</p> <p>Isobutane = 17 %</p> <p>n-Propane = 11 %</p> <p>Butylene and Ethane = rest.</p> <p>Calorific Value Its Calorific Value is 27,000 kcals/m³.</p> <p>Uses</p> <ol style="list-style-type: none"> i. It is used as a fuel for domestic cooking. ii. Used for heating industrial furnaces. iii. Used as an alternate for Gasoline in automobiles. 		

58.	List down significance of Ultimate analysis.	CO5	BTL1
	<p>i) Carbon and Hydrogen</p> <p>Higher the % of carbon and hydrogen, better the quality of coal and higher is its calorific value.</p> <p>ii) Nitrogen</p> <ol style="list-style-type: none"> Nitrogen does not have any calorific value, and its presence in coal is undesirable. Good quality coal should have very little nitrogen content. <p>iii) Sulphur</p> <p>Though sulphur increases the calorific value, its presence in coal is undesirable because</p> <ol style="list-style-type: none"> The combustion products of sulphur, i.e, SO₂ and SO₃ are harmful and have corrosion effects on equipments. <p>iv) Oxygen</p> <ol style="list-style-type: none"> Lower the % of oxygen higher is its calorific value. As the oxygen content increases its moisture holding capacity increases and the calorific value of the fuel is required. 		
59.	Explain determination of nitrogen by kjeldahl's method	CO5	BTL2
	<p>Determination of Nitrogen in Coal :</p> <p>1 gram of accurately weighed powdered coal is digested in conc. H₂SO₄ in Kjeldahl's flask and heated. It is treated with excess of KOH when the solution</p>		

becomes clear. Liberated ammonia is distilled over and absorbed in a known volume of standard solution of acid. The unused acid is determined by back titration with standard solution of NaOH.



$$\% \text{ Nitrogen} = \frac{\text{Volume of acid Consumed} \times \text{Normality} \times 14}{\text{WEIGHT OF COAL SAMPLE TAKEN} \times 1000} \times 100$$

60.	Give the composition and uses of CNG.	CO5	BTL1
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CNG(Compressed Natural Gas):

It is a natural gas compressed to high pressure.

Composition: Methane (CH₄)=70-90%, Ethylene(C₂H₂) = 5-10%, H₂=3% & Rest= CO +CO₂

Calorific Value: 12,000–14000 Kcal/m³

Uses: Mainly used as automobile fuel, as a domestic fuel.

UNIT: V GREEN CHEMISTRY

61.	Explain the various sources of Bio Diesel.	CO6	BTL2
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Bio diesel is a natural and renewable domestic fuel alternative for diesel engines made from vegetable oils such as soya bean oil, palm oil, peanut oil & Sunflower seed oil.

62.	Explain the constituents of composites.	CO6	BTL1
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Constituents of composites:

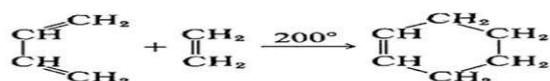
Composites consist of body constituents and structural constituents. The body constituent encloses the composite and gives it its bulk form. The continuous matrix phase is the body constituent. The structural constituent determines the internal structure of the composite, and is known as 'dispersed phase'. The Matrix phase may be metal, ceramics or polymers. The dispersed phase can be fiber, particle, flake, whisker etc.

63.	Explain atom economy in green chemistry by taking suitable example.	CO6	BTL2
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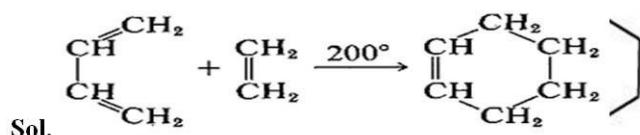
1) Atom Economy : Atom Economy is defined as the ratio of the weight of the target molecule to the formula weight of all the starting materials and the reagents.

$$\% \text{ Atom Economy} = \frac{\text{Mass of atoms in desired products}}{\text{Total mass of atoms in reactants}} \times 100 \%$$

1. Examples of **Atom Economic** reactions:



Calculate % atom economy for cyclo addition reaction of ethene and butadiene to form cyclohexene.



1,3-Butadiene(54) Ethene(28) Cyclo hexane(82)

$$\% \text{ Atom economy} = \frac{\text{mass of atoms in desired product}}{\text{total mass of atoms in reactants}} \times 100$$

$$= \frac{82}{82} \times 100 = 100\%$$

64.	Differentiate between Matrix and Reinforcement in a composite.	CO6	BTL2
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Matrix phase:

It is a continuous body constituent of composite, enclose the composite and gives it bulk form. The Matrix phase maybe a **metal, ceramic or polymer**

Dispersed phase or Reinforcement:

It is a structural constituent of composite ,which determines the internal structure of composite.

Dispersed phase maybe fibres, particles, flakes and whiskers

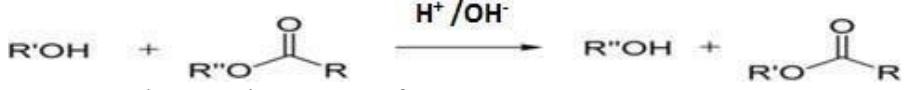
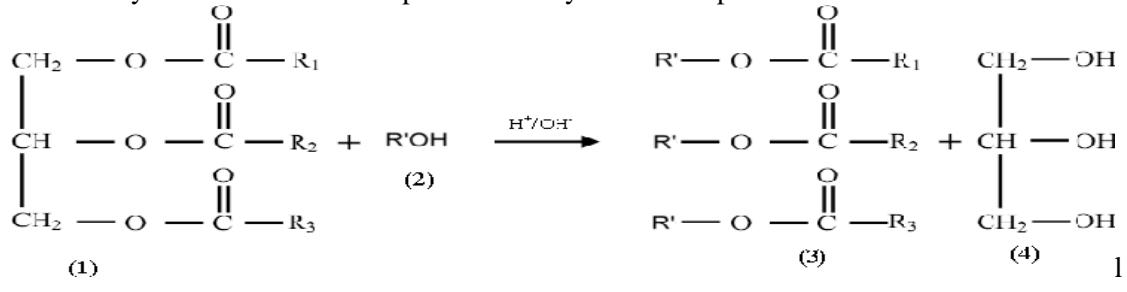
65.	Define composite material.	CO6	BTL1
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Composite: A Composite is a material made from two or more different materials which have distinct physical and chemical properties those individual materials that combined

Examples:

Wood (a composite of cellulose fibres & lignin)

Bone (a composite of strong protein Collagen ,and hard material apatite)

	<p>The earliest man-made composite materials were straw and mud combined to form bricks for building construction</p> <p>Concrete is the most common artificial composite material of all and typically consists of gravel (aggregate) held with a matrix of cement.</p>	
66.	What is trans esterification?	CO6 BTL1
	<p>Bio diesel is produced from the seeds of Jatropha and Rape seed vegetable oils and these are not used directly as diesel fuel due to their high viscosities & high flash point. Therefore Trans – esterification of Vegetable oils is done to reduce the viscosity.</p> <p><i>Transesterification is “the process of conversion of vegetable oils/animal oils/fats into biodiesel”.</i></p>  <p>In transesterification, the organic group R'' of an ester exchanges with the organic group R' of an alcohol. These reactions are often catalyzed by an acid or base.</p> <p>E.g.; Triglycerides(1) reacts with alcohols(2) to give alkyl esters(3) of a fatty acid and glycerol(4)</p> <p>Base catalyzed transesterification predominantly is used for production of bio diesel</p> 	
67.	Give example of clean technology.	CO6 BTL2
	<p>Green technology or clean technology is processes that reduce or eliminate the use and generation of hazardous substances'.</p> <p>Examples:</p> <ol style="list-style-type: none"> 1. Atom Economy-A reaction to be considered as green synthesis, the atom economy must be very high, approaching or equal to 100%. 2. Catalysis: catalysts increases specificity of the reaction and reduces the formation of byproducts .A catalyst also lowers active at ion energy of the energy ,there by reducing the energy consumption . <p style="text-align: center;">1.</p>	

68.	Explain carbon neutrality of bio – diesel.	CO6	BTL2				
	Bio diesel is a Carbon neutral: Biodiesel is said to be carbon-neutral because the carbon dioxide that is absorbed by the plants for photosynthesis process is equal to the carbon dioxide that is released when the fuel is burnt .So, there will be no net increase of CO ₂ emission to the atmosphere						
69.	Write any four properties of composites.	CO6	BTL2				
	<p>Characteristic properties of Composite Materials:</p> <p>The composites show extra ordinary combination of properties like toughness and strength with low weights & high temperature resistance.</p> <p>Compared to steel and aluminum ,composites are lighter ,have low coefficient of thermal expansion and</p> <p>Have superior strength, stiffness &fatigue resistance.</p> <p>They have better corrosion & oxidation-resistance</p>						
70.	What is carbon neutrality of biodiesel?	CO6	BTL1				
	Bio diesel is a Carbon neutral: Biodiesel is said to be carbon-neutral because the carbon dioxide that is absorbed by the plants for photosynthesis is process is equal to the carbon dioxide that is released when the fuel is burnt. So,there will be no net increase of CO ₂ emission to the atmosphere						
71.	Define atom economy.	CO6	BTL1				
	<p>1)Atom Economy : Atom Economy is defined as the ratio of the formula weight of the target molecule to the formula weight of all the starting materials and the reagents.</p> $\% \text{ Atom Economy} = \frac{\text{Mass of atoms in desired products}}{\text{Total mass of atoms in reactants}} \times 100 \%$						
72.	Give concept &importance of Green Chemistry.	CO6	BTL1				
73.	Define green catalyst.	CO6	BTL2				
	Catalysis : Catalytic reagents (as selective as possible) are superior to stoichiometric reagents						
	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="padding: 5px;">Stoichiometric Approach(X)</td> </tr> <tr> <td style="padding: 5px; text-align: center;"> </td> </tr> <tr> <td style="padding: 5px;">Catalytic Approach(✓)</td> </tr> <tr> <td style="padding: 5px; text-align: center;"> </td> </tr> </table>			Stoichiometric Approach(X)		Catalytic Approach(✓)	
Stoichiometric Approach(X)							
Catalytic Approach(✓)							
74.	Write any four engineering applications of composite materials.	CO6	BTL2				

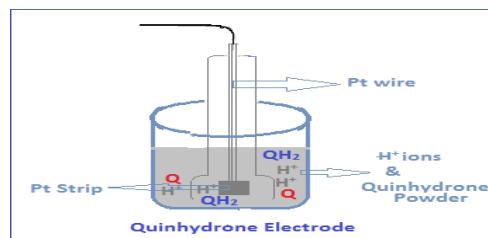
	Applications of composites: Transportation: Composites are used in the manufacturing of automobile parts, racing vehicle components and engine parts. Marine: They are used as propeller shafts, hulls, spars (for racing boats) etc. Aerospace: They are used in military aircrafts, helicopters, missiles and rocket components etc. Consumer product: They are used in sporting goods like tennis rackets, and in musical instruments etc.	
Composite Applications in Building & Construction		
75.	Give the synthesis of Biodiesel.	CO6 BTL2
	Bio diesel is produced from the seeds of Jatropha and Rape seed vegetable oils and these are not used directly as diesel fuel due to their high viscosities & high flash point. Therefore Transesterification of Vegetable oils is done to reduce the viscosity. <i>Transesterification is “the process of conversion of vegetable oils/animal oils/fats into biodiesel”.</i>	
$\text{R}'\text{OH} + \text{R}''\text{O}-\text{C}(=\text{O})-\text{R} \xrightarrow{\text{H}^+/\text{OH}^-} \text{R}''\text{OH} + \text{R}'\text{O}-\text{C}(=\text{O})-\text{R}$ <p>Intranesterification, the organic group R'' of an ester exchanges with the organic group R' of an alcohol. These reactions are often catalyzed by an acid or base.</p>		
UNIT: I ELECTROCHEMISTRY AND BATTERY CHEMISTRY		
	LONG ANSWER QUESTIONS	CO
76.	a) Write the cell reaction and calculate the emf of the cell at 25° C. $\text{Zn} / \text{Zn}^{+2} // \text{Fe}^{+3} / \text{Fe}^{2+} / \text{Pt}$ $(0.01\text{ M}) \qquad \qquad (0.1\text{ M})$ $(E^\circ_{\text{Zn/Zn}^{2+}} = 0.76\text{ V}) \text{ and } (E^\circ_{\text{Fe}^{3+}/\text{Fe}^{2+}} = 0.77\text{ V})$	CO1 BTL3

77.	Explain how pH is determined using quinhydrone electrode.	CO1	BTL3
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Quinhydrone Electrode:

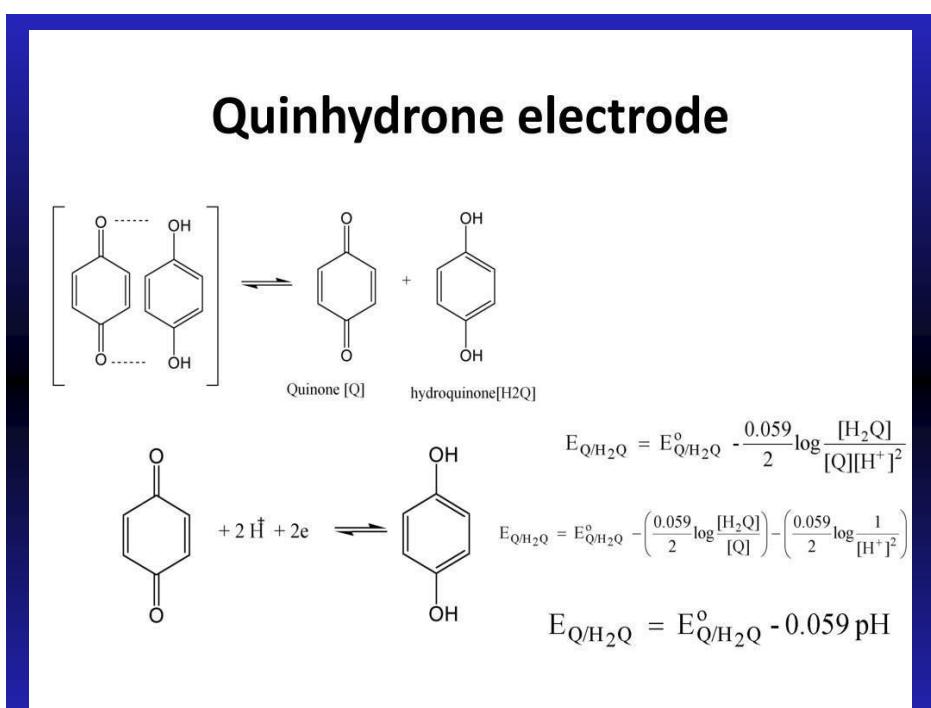
Construction and working of Quinhydrone electrode:

The Quinhydrone electrode is an example of redox electrode, which is constructed by adding a pinch of Quinhydrone powder, which is an equimolar mixture of quinone and hydroquinone to a acid solution, under test, taken in a beaker. An inert Pt electrode is dipped into the solution for making electrical contact. The electrode is represented as $\text{H}^+; \text{Q} \rightleftharpoons \text{QH}/\text{Pt}_{(\text{aq})}$



2

It will either act as a anode or cathode depending on the other electrode to which it is connected.



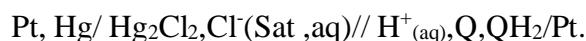
Determination of pH of a solution using quinhydrone electrode:

The electrode potential of Quinhydrone electrode, which is reversible to H^+ ions, depends on pH of a solution; therefore it is used to determine pH of a

solution. To determine pH of a solution, quinhydrone electrode is combined with

a

reference electrode like calomel electrode. The cell consists of Quinhydrone and Calomel electrode is represented as,

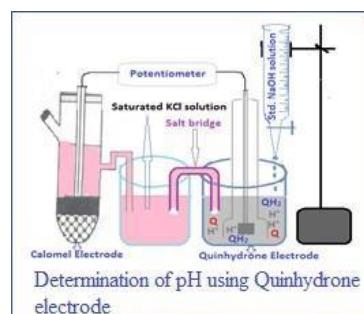


$$E_{cell} = E_{QHE} - E_{SCE}$$

$$E_{cell} = 0.699\text{V} - 0.0591 \text{ pH} - .242\text{V}$$

$$E_{cell} = 0.457 - 0.0591 \text{ pH}$$

$$pH = \frac{0.457 - E_{cell}}{0.0591}$$



78. For a cell $\text{Zn(s)/Zn}^{2+}(0.01\text{M} // \text{H}^+(0.01\text{M}) / \text{Pt}|\text{H}_2(1\text{atm})$, calculate emf of the cell if standard electrode potentials of Zinc electrode and Hydrogen electrode are +0.76V and 0.00V respectively.

CO1 BTL3

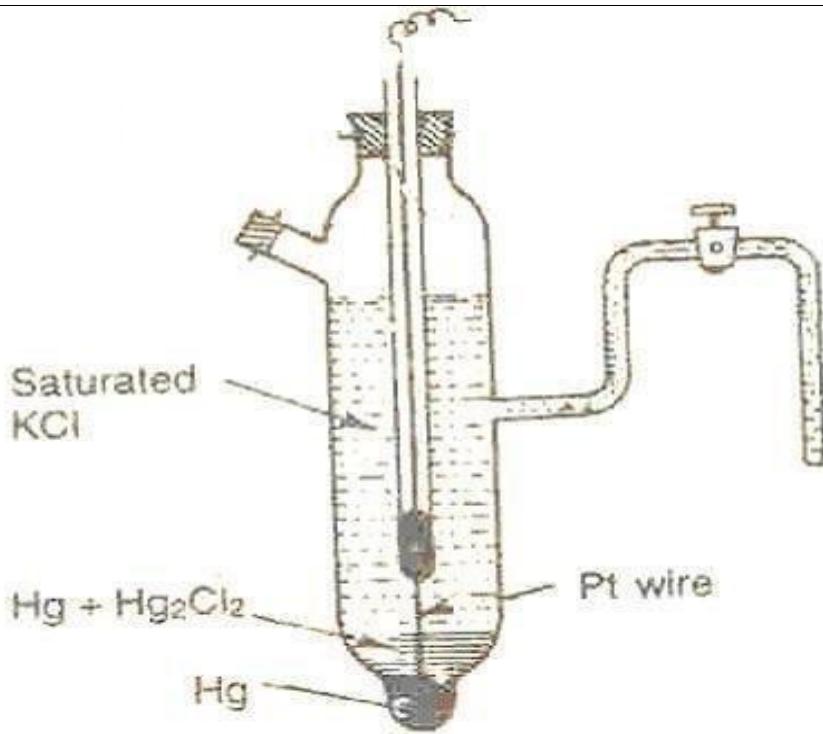
79. Differentiate between Electrolytic cell from electrochemical cell.

CO1 BTL2

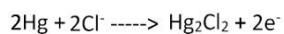
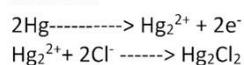
Electrolytic Cell	Galvanic cell
Electrical energy (from an external source) is converted into chemical energy.	Chemical energy (of a redox reaction) is converted into electrical energy.
The electrodes may be made of same or different metals.	The electrodes are made of dissimilar metals.
At the electrodes, non-spontaneous reaction take place only when the electrical energy is supplied.	At the electrodes, spontaneous redox reaction take place.
Anode – Positive ; Cathode - Negative	Anode – Negative ; Cathode – Positive
Ions are discharged on both the electrodes	Ions are discharged only on the cathode.
Both electrodes are inserted in the same electrolytic solution.	Each electrode is dipped in electrolytic solution of its own ions.

80.	What are reference electrodes? Describe the construction, working and applications of calomel electrode.	CO1	BTL3
	<p>Calomel electrode: It consists of mercury at the bottom over which a paste of mercury mercurous chloride is placed. A solution of potassium chloride is then placed over the paste. A platinum wire sealed in a glass tube helps in making the electrical contact. The electrode is connected with the help of the side tube on the left through a salt bridge with the other electrode to make a complete cell. The electrode is represented as Pt, Hg / Hg_2Cl_2, Cl^- (aq) The potential of the calomel electrode depends upon the concentration of the potassium chloride solution.</p>		

	<p>If it acts as anode, it involves oxidation.</p> $2\text{Hg} \longrightarrow \text{Hg}_2^{2+} + 2\text{e}^-$ $\text{Hg}_2^{2+} + 2\text{Cl}^- \longrightarrow \text{Hg}_2\text{Cl}_2$ <hr/> $2\text{Hg} + 2\text{Cl}^- \longrightarrow \text{Hg}_2\text{Cl}_2 + 2\text{e}^-$ <hr/> <p>When it acts as anode, mercury is converted to Mercurous ions. Mercurous ions would combine with Cl^- ions furnished by KCl to form sparingly soluble Hg_2Cl_2 which results there is a fall in the concentration of Cl^- ions.</p>	<p>If it acts as cathode it involves reduction.</p> $\text{Hg}_2\text{Cl}_2 \longrightarrow \text{Hg}_2^{2+} + 2\text{Cl}^-$ $\text{Hg}_2^{2+} + 2\text{e}^- \longrightarrow 2\text{Hg}$ <hr/> $\text{Hg}_2\text{Cl}_2 + 2\text{e}^- \longrightarrow 2\text{Hg} + 2\text{Cl}^-$ <hr/> <p>When it acts as cathode, Hg_2^{2+} ions, furnished by the sparingly soluble Hg_2Cl_2, would be discharged at the electrode and there is an increase in the concentration of Cl^- ions. Thus, Calomel electrode is said to be reversible to Cl^- ions.</p>	
81.	Write the electrode representation and electrode reaction for the reduction process of Calomel electrode	CO1	BTL3
	calomel electrode: It consists of mercury at the bottom over which a paste of mercury mercurous chloride is placed. A solution of potassium chloride is then placed over the paste. A platinum wire sealed in a glass tube helps in making the electrical contact. The electrode is connected with the help of the side tube on the left through a salt bridge with the other electrode to make a complete cell. The electrode is represented as Pt, Hg/ Hg_2Cl_2 , Cl^- (aq) The potential of the calomel electrode depends upon the concentration of the potassium chloride solution.		

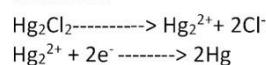


If it acts as anode, it involves oxidation.



When it acts as anode, mercury is converted to Mercurous ions. Mercurous ions would combine with Cl^- ions furnished by KCl to form sparingly soluble Hg_2Cl_2 which results there is a fall in the concentration of Cl^- ions.

If it acts as cathode it involves reduction.

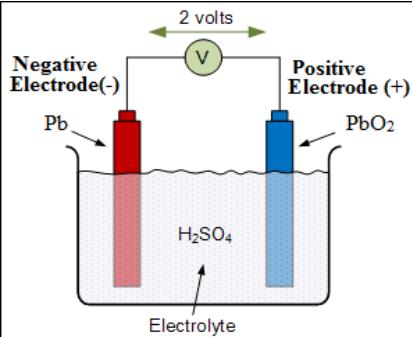


When it acts as cathode, Hg_2^{2+} ions, furnished by the sparingly soluble Hg_2Cl_2 , would be discharged at the electrode and there is an increase in the concentration of Cl^- ions. Thus, Calomel electrode is said to be reversible to Cl^- ions.

82.	What is secondary battery? Describe the construction working and applications of Lead acid battery.	CO1	BTL3
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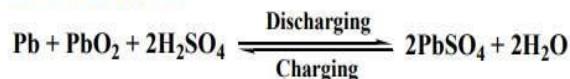
Lead-Acidbattery

The **lead acid battery** was invented in 1859 by French physicist Gaston Planté. It is the oldest rechargeable battery.

<p>Construction</p>  <p>It is a secondary battery.</p>	<p>Negative electrode: Spongy Lead (Pb)</p> <p>Positive electrode: Lead plate coated with PbO₂</p> <p>Electrolyte: 30% H₂SO₄ solution</p> <p>It consists of a group of Lead plates coated with spongy Lead, which acts as anode and alternating with a group of lead plates coated with PbO₂ acts as cathode. These two are separated by insulating material like thin wooden or fibre glass sheets. These plates are immersed in a solution of about 30% H₂SO₄.</p> <p>The cell is represented as,</p> <p>Pb(s), PbSO₄(s)/H₂SO₄(aq)(30%)/PbSO₄(s), PbO₂(s), Pb(s)</p>				
<p>Working</p>	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: center; padding: 5px;">During Discharging</th> <th style="text-align: center; padding: 5px;">During Charging</th> </tr> </thead> <tbody> <tr> <td style="padding: 10px;"> <p>During discharging, Lead-Acid battery acts as electrochemical cell (Voltaic cell).</p> <p>At Negative Electrode :(Anode):</p> $\text{Pb}(s) \longrightarrow \text{Pb}^{2+} + 2\text{e}^-$ $\text{Pb}^{2+} + \text{SO}_4^{2-} \longrightarrow \text{PbSO}_4 \text{ (Precipitate)}$ <hr/> $\text{Pb}(s) + \text{SO}_4^{2-} \longrightarrow \text{PbSO}_4(s) + 2\text{e}^-$ </td> <td style="padding: 10px;"> <p>During charging, Lead-Acid battery acts as a electrolytic cell.</p> <p>At Negative Electrode (Cathode):</p> $\text{PbSO}_4(s) \longrightarrow \text{Pb}^{2+} + \text{SO}_4^{2-}$ $\text{Pb}^{2+} + 2\text{e}^- \longrightarrow \text{Pb}(s)$ <hr/> $\text{PbSO}_4 + 2\text{e}^- \longrightarrow \text{Pb}(s) + \text{SO}_4^{2-}$ </td></tr> </tbody> </table>	During Discharging	During Charging	<p>During discharging, Lead-Acid battery acts as electrochemical cell (Voltaic cell).</p> <p>At Negative Electrode :(Anode):</p> $\text{Pb}(s) \longrightarrow \text{Pb}^{2+} + 2\text{e}^-$ $\text{Pb}^{2+} + \text{SO}_4^{2-} \longrightarrow \text{PbSO}_4 \text{ (Precipitate)}$ <hr/> $\text{Pb}(s) + \text{SO}_4^{2-} \longrightarrow \text{PbSO}_4(s) + 2\text{e}^-$	<p>During charging, Lead-Acid battery acts as a electrolytic cell.</p> <p>At Negative Electrode (Cathode):</p> $\text{PbSO}_4(s) \longrightarrow \text{Pb}^{2+} + \text{SO}_4^{2-}$ $\text{Pb}^{2+} + 2\text{e}^- \longrightarrow \text{Pb}(s)$ <hr/> $\text{PbSO}_4 + 2\text{e}^- \longrightarrow \text{Pb}(s) + \text{SO}_4^{2-}$
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<p>At Positive Electrode (Cathode):</p> $\text{PbO}_2(s) + 4\text{H}^+ + 2\text{e}^- \longrightarrow \text{Pb}^{2+} + 2\text{H}_2\text{O(l)}$ $\text{Pb}^{2+} + \text{SO}_4^{2-} \longrightarrow \text{PbSO}_4 \text{ (Precipitate)}$ <hr/> $\text{PbO}_2(s) + 4\text{H}^+ + 2\text{SO}_4^{2-} + 2\text{e}^- \longrightarrow \text{PbSO}_4(s) + 2\text{H}_2\text{O(l)}$	<p>At Positive Electrode (Anode):</p> $\text{PbSO}_4(s) \longrightarrow \text{Pb}^{2+} + \text{SO}_4^{2-}$ $\text{Pb}^{2+} + 2\text{H}_2\text{O} \longrightarrow \text{PbO}_2(s) + 4\text{H}^+ + 2\text{e}^-$ <hr/> $\text{PbSO}_4(s) + 2\text{H}_2\text{O(l)} \longrightarrow \text{PbO}_2(s) + 4\text{H}^+ + 2\text{SO}_4^{2-} + 2\text{e}^-$
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Net cell reaction:



During discharging H_2SO_4 is consumed and its concentration decreases. During charging H_2SO_4 is regenerated and its original concentration is restored. The variation of concentration of the acid and hence the extent of discharge or charge of the cell can be easily monitored by changes in specific gravity of the acid. During charging, Specific gravity of H_2SO_4 increases whereas during discharge specific gravity decreases.

Voltage of each cell is 2V. In general, lead-Acid battery consists of such 6 cells which are connected in series to get higher voltage(12V)

Applications: Lead acid -batteries are used in telecommunication, power systems, radio, and television systems, solar, UPS, electric vehicles, automobile, emergency lights.

Advantages Low maintenance, Low Cost,

Disadvantages Heavy in weight, Lead is not environmentally friendly.

APPLICATIONS

systems, solar, UPS, electric vehicles, automobile, emergencylights.

:note : refer handwritten pdf

83.	What is Lithium-ion batteries? Explain their advantages and applications.	CO1	BTL2
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Lithium–IonBattery(LIB)

Lithiumionbatteryisasecondarybattery.Lithiumionbatteriesarerechargeablebatteries.

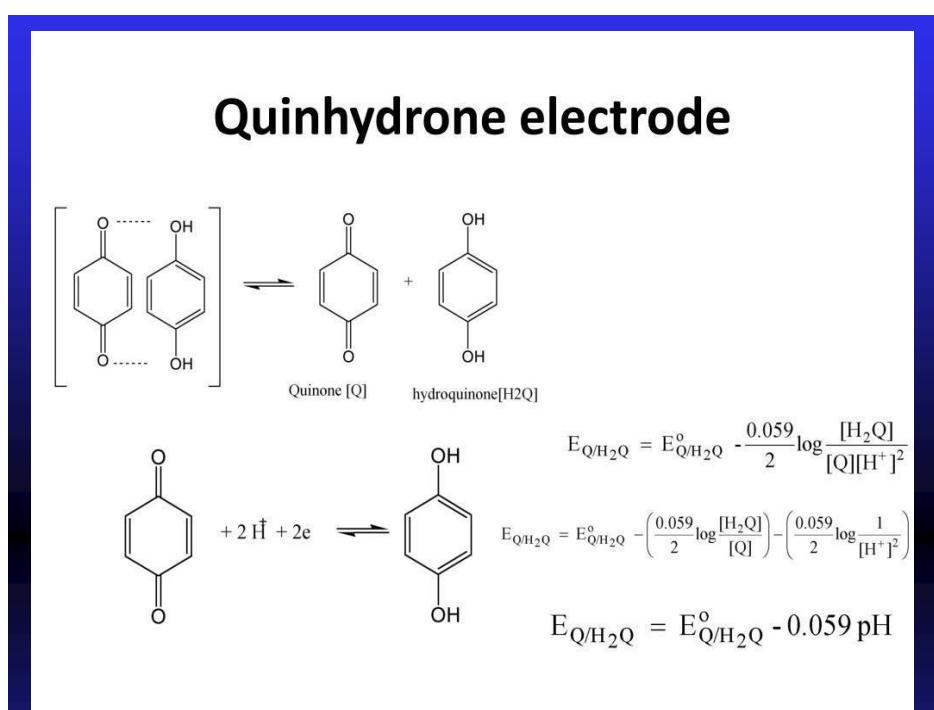
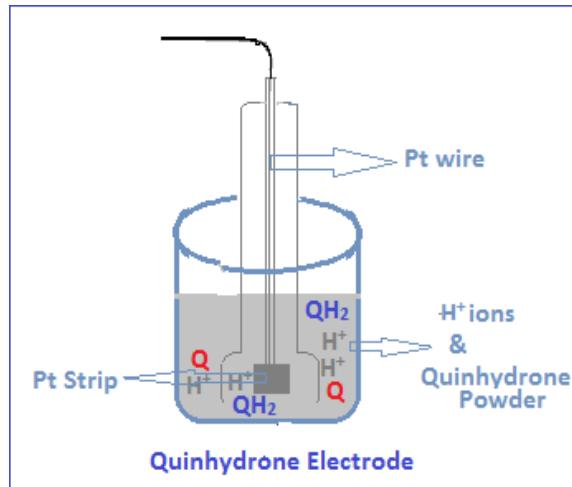
	<p>Construction</p> <p>The primary functional components of a Li-ion battery are:</p> <p>Anode (-ve): Porous Graphite</p> <p>Cathode (+ve): Lithium metal oxide ($\text{Li}_{1-x}\text{CoO}_2$)</p> <p>Electrolyte: A non-aqueous medium used as an electrolyte, usually which is a mixture of organic carbonate (ethylene carbonate) containing complex ($[\text{LiPF}_6]$) of lithium ions.</p> <p>Anode and cathode are separated by electrical insulating separator (diaphragm) which is permeable to lithium ions.</p>	
84.	What is reference electrode? Give two examples and represent them and write their electrode reaction for reduction process.	CO1 BTL2
	<p>Calomel electrode-Secondary Reference electrode</p> <p>Electrode construction</p> <p>General Representation: Pt, $\text{Hg}(\text{l})$, $\text{Hg}_2\text{Cl}_2(\text{s})/\dots\dots\dots\text{KCl}$</p> <p>Working</p> <p>When it acts as a cathode</p> $\text{Hg}_2^{2+} + 2\text{e}^- \longrightarrow 2\text{Hg}$ $\text{Hg}_2\text{Cl}_2 \longrightarrow \text{Hg}_2^{2+} + 2\text{Cl}^-$ <p>When it acts as an anode</p> $2\text{Hg} \longrightarrow \text{Hg}_2^{2+} + 2\text{e}^-$ $\text{Hg}_2^{2+} + 2\text{Cl}^- \longrightarrow \text{Hg}_2\text{Cl}_2$ <p>The net reversible reaction is:</p> $\text{Hg}_2\text{Cl}_2 + 2\text{e}^- \longleftrightarrow \text{Hg}_2^{2+} + 2\text{Cl}^-$	
85.	Write the electrode representation and electrode reaction for the reduction process of Quinhydrone electrode	CO1 BTL3
	<p>Quinhydrone Electrode:</p> <p>Construction and working of Quinhydrone electrode:</p> <p>The Quinhydrone electrode is an example of redox electrode, which is constructed by adding a pinch of Quinhydrone powder, which is an equimolar mixture of quinine and</p>	

hydroquinone to a acid solution, undertest,taken in abeaker.An inert Pt electrode is dipped into the solution form eletrical contact.
The electrode is represented as $\text{H}^+; \text{Q}; \text{QH}/\text{Pt}$.

(aq)

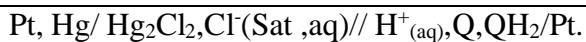
2

It will either act as anode or cathode depending on the other electrode to which it is connected.



Determination of pH of a solution using quinhydrone electrode:

The electrode potential of Quinhydrone electrode, which is reversible to H^+ ions, depends on pH of a solution; therefore it is used to determine pH of a solution. To determine pH of a solution, quinhydrone electrode is combined with a reference electrode like calomel electrode. The cell consists of Quinhydrone and Calomel electrode represented as,

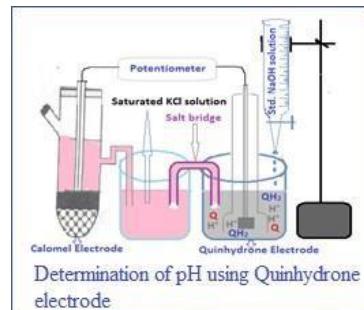


$$E_{cell} = E_{QHE} - E_{SCE}$$

$$E_{cell} = 0.699\text{V} - 0.0591 \text{ pH} - .242\text{V}$$

$$E_{cell} = 0.457 - 0.0591 \text{ pH}$$

$$pH = \frac{0.457 - E_{cell}}{0.0591}$$



86.	Write the cell reaction and calculate the EMF of the cell $\text{Cu} \text{Cu}^{2+} (0.1 \text{ M}) \parallel \text{H}^+ (0.01 \text{ M}), \text{H}_2 (1 \text{ atm}) \text{Pt}$	CO1	BTL3
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87.	Determine the EMF of the following cell at 25°C with the help of Nernst equation by finding the net reaction. $\text{Mg} \text{Mg}^{2+} (0.01 \text{ M}) \parallel \text{Cu}^{2+} \text{Cu}$ $E^0(\text{Mg}^{2+} \text{Mg}) = - 2.364\text{V} \text{ & } E^0(\text{Cu} \text{Cu}^{2+}) = - 0.334 \text{ V}$	CO1	BTL3
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88.	Differentiate between primary, secondary and fuel cell.	CO1	BTL2
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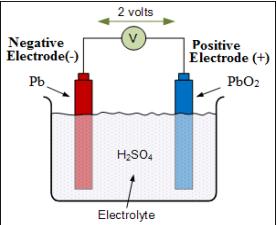
Distinction between Primary, Secondary & Fuel cells

Primary	Secondary	Fuel cells
1) It only acts as galvanic or voltaic cell. i.e., produces electricity	1) It acts as galvanic or voltaic cell while discharging (produces electricity) and acts as electrolytic cell (consumes electricity)	1) It is a simple galvanic or voltaic cell. i.e., produces electricity
2) Cell reaction is not reversible.	2) Cell reaction is reversible.	2) Cell reaction is reversible.
3) Can't be recharged.	3) Can be recharged	3) Energy can be withdrawn continuously
4) Can be used as long as the active materials are present	4) Can be used again and again by recharging.	4) Reactants should be replenished continuously. it does not store energy.
eg: Leclanche cell or Dry cell, Lithium cell.	eg: Lead storage battery, Ni-Cd battery, Lithium ion cell	eg: $\text{H}_2 \& \text{O}_2$ Fuel cell $\text{CH}_3\text{OH} \& \text{O}_2$ Fuel cell
<u>Uses:</u> In Pace makers watches, Transistors, radios ect.	<u>Uses:</u> In electronic equipments, automobile equipments, digital cameras, laptops, flash light.	<u>Uses:</u> Great use in space vehicles due to its light weight (product of is source of fresh water for astronauts)

89.	List down the applications of calomel electrode and Nernst equation.	CO1	BTL2
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Applications of Nernst Equation:

	<p>1. Nernst equation is used to study the effect of electrolyte concentration on electrode potential.</p> <p>2. Nernst equation can be used to calculate cell potentials/Electrode potentials under non-standard and non-equilibrium condition.</p> <p>3. Determination of unknown concentration of one of the ionic species involved in a redox reaction is possible with help of Nernst equation provided E^0 concentration of other ionic species is known.</p>		
	<h3>SCE Applications</h3> <p>The SCE is used in <u>pH</u> measurement, <u>cyclic voltammetry</u> and general aqueous <u>electrochemistry</u>.</p> <p>This electrode and the <u>silver/silver chloride reference electrode</u> work in the same way. In both electrodes, the activity of the metal ion is fixed by the solubility of the metal salt.</p> <p>The calomel electrode contains mercury, which poses much greater health hazards than the silver metal used in the Ag/AgCl electrode.</p>		<i>cell</i>
90.	<p>What is secondary battery? Explain in detail construction, working and applications of lead-acid battery.</p> <p>Secondary batteries are those batteries which can be recharged by passing electric current through them and hence can be used over again e.g., lead storage battery.</p> <p>Lead Acid Battery</p>	CO1	BTL3

<h3>Construction</h3>  <p>It is a secondary battery.</p>	<p>Negative electrode: Spongy Lead (Pb)</p> <p>Positive electrode: Lead plate coated with PbO₂</p> <p>Electrolyte: 30% H₂SO₄ solution</p> <p>n.</p> <p>It consists of a group of Lead plates coated with spongy Lead, which acts as anode and alternating with a group of lead plates coated with PbO₂ acts as cathode. These two are separated by insulating material like thin wooden or fibre glass sheets. These plates are immersed in a solution of about 30% H₂SO₄.</p> <p>The cell is represented as,</p> <p>Pb(s), PbSO₄(s)/H₂SO₄(aq)(30%)/PbSO₄(s), PbO₂(s), Pb(s)</p>			
<h3>Working</h3> <table border="1" data-bbox="235 1064 1352 1567"> <thead> <tr> <th data-bbox="235 1064 747 1163">During Discharging</th> <th data-bbox="747 1064 1352 1163">During Charging</th> </tr> </thead> <tbody> <tr> <td data-bbox="235 1163 747 1567"> During discharging, Lead-Acid battery acts as an electrochemical cell (Voltaic cell). At Negative Electrode : (Anode): $\text{Pb(s)} \rightarrow \text{Pb}^{2+} + 2\text{e}^-$ $\text{Pb}^{2+} + \text{SO}_4^{2-} \rightarrow \text{PbSO}_4 \text{ (Precipitate)}$ $\text{Pb(s)} + \text{SO}_4^{2-} \rightarrow \text{PbSO}_4(\text{s}) + 2\text{e}^-$ </td><td data-bbox="747 1163 1352 1567"> During charging, Lead-Acid battery acts as an electrolytic cell. At Negative Electrode (Cathode): $\text{PbSO}_4(\text{s}) \rightarrow \text{Pb}^{2+} + \text{SO}_4^{2-}$ $\text{Pb}^{2+} + 2\text{e}^- \rightarrow \text{Pb(s)}$ $\text{PbSO}_4 + 2\text{e}^- \rightarrow \text{Pb(s)} + \text{SO}_4^{2-}$ </td></tr> </tbody> </table>	During Discharging	During Charging	During discharging, Lead-Acid battery acts as an electrochemical cell (Voltaic cell). At Negative Electrode : (Anode): $\text{Pb(s)} \rightarrow \text{Pb}^{2+} + 2\text{e}^-$ $\text{Pb}^{2+} + \text{SO}_4^{2-} \rightarrow \text{PbSO}_4 \text{ (Precipitate)}$ $\text{Pb(s)} + \text{SO}_4^{2-} \rightarrow \text{PbSO}_4(\text{s}) + 2\text{e}^-$	During charging, Lead-Acid battery acts as an electrolytic cell. At Negative Electrode (Cathode): $\text{PbSO}_4(\text{s}) \rightarrow \text{Pb}^{2+} + \text{SO}_4^{2-}$ $\text{Pb}^{2+} + 2\text{e}^- \rightarrow \text{Pb(s)}$ $\text{PbSO}_4 + 2\text{e}^- \rightarrow \text{Pb(s)} + \text{SO}_4^{2-}$
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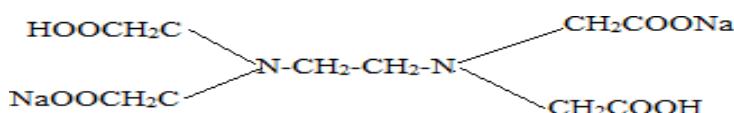
	<p>At Positive Electrode (Cathode):</p> $\text{PbO}_2(s) + 4\text{H}^+ + 2\text{e}^- \longrightarrow \text{Pb}^{2+} + 2\text{H}_2\text{O(l)}$ $\text{Pb}^{2+} + \text{SO}_4^{2-} \longrightarrow \text{PbSO}_4 \text{ (Precipitate)}$ <hr/> $\text{PbO}_2(s) + 4\text{H}^+ + 2\text{SO}_4^{2-} + 2\text{e}^- \longrightarrow \text{PbSO}_4(s) + 2\text{H}_2\text{O(l)}$	<p>At Positive Electrode (Anode):</p> $\text{PbSO}_4(s) \longrightarrow \text{Pb}^{2+} + \text{SO}_4^{2-}$ $\text{Pb}^{2+} + 2\text{H}_2\text{O} \longrightarrow \text{PbO}_2(s) + 4\text{H}^+ + 2\text{e}^-$ <hr/> $\text{PbSO}_4(s) + 2\text{H}_2\text{O(l)} \longrightarrow \text{PbO}_2(s) + 4\text{H}^+ + 2\text{SO}_4^{2-} + 2\text{e}^-$				
Net cell reaction:						
$\text{Pb} + \text{PbO}_2 + 2\text{H}_2\text{SO}_4 \xrightleftharpoons[\text{Charging}]{\text{Discharging}} 2\text{PbSO}_4 + 2\text{H}_2\text{O}$						
<p>During discharging H_2SO_4 is consumed and its concentration decreases. During charging H_2SO_4 regenerated and its original concentration is restored. The variation of concentration of the acid ar hence the extent of discharge or charge of the cell can be easily monitored by changes in specific gravity of the acid. During charging, Specific gravity of H_2SO_4 increases whereas during discharge specific gravity decreases.</p>						
<p>Voltage of each cell is 2V. In general, lead-Acid battery consists of such 6 cells which are connected series to get higher voltage(12V)</p>						
<p>Applications: Lead acid -batteries are used in telecommunication, power systems, radio, and televisio systems, solar, UPS, electric vehicles, automobile, emergency lights.</p>						
<table border="1"> <tr> <td>Advantages</td><td>Low maintenance, Low Cost,</td></tr> <tr> <td>Disadvantages</td><td>Heavy in weight, Lead is not environmentally friendly.</td></tr> </table>		Advantages	Low maintenance, Low Cost,	Disadvantages	Heavy in weight, Lead is not environmentally friendly.	
Advantages	Low maintenance, Low Cost,					
Disadvantages	Heavy in weight, Lead is not environmentally friendly.					

UNIT- II WATER CHEMISTRY AND CORROSION

91. Explain principle and method of determination of hardness of water by EDTA method. CO2 BTL3

I. Principle: Hardness of water is estimated by a complexometric titration which

involves EDTA (Ethelene Diamine Acetic Acid) as a complexing agent. EDTA forms 1:1 stable, colourless complexes with $\text{Ca}^{2+}/\text{Mg}^{2+}$ ions at pH = 9-10.



Structure of di sodium salt of EDTA

In this titration, Eriochrome Black-T (EBT) is used as indicator which shows blue colour in its free state. When EBT is added to Hard water sample buffered to pH = 10, the water sample turns wine-red colour due to the formation of unstable $[\text{Ca-EBT}]/[\text{Mg-EBT}]$ complex.



During titration, EDTA first combines with freely available $\text{Ca}^{+2}/\text{Mg}^{+2}$ ions of sample water to form stable and colourless $[\text{Ca-EDTA}]/[\text{Mg-EDTA}]$ complex and when all freely available $\text{Ca}^{+2}/\text{Mg}^{+2}$ ions are complexed with EDTA; further added EDTA displaces EBT from $[\text{Ca-EBT}/\text{Mg-EBT}]$ complex. Thus, at the endpoint the colour of the solution changes from wine red to blue.

Experimental procedure:

(a). Standardization of EDTA:

50mL of standard hard water is taken in a clean conical flask, 10mL of buffer and 2 or 3 drops EBT indicator is added to it. The colour of the solution changes to wine red. This solution titrated against EDTA solution taken in burette till the colour changes to blue. Let the volume of EDTA consumed be V_1 mL.

(b). Determination of Total Hardness:

50mL of hard water sample is taken in a conical flask and the procedure carried out as under standardization. Let the volume of EDTA consumed be V_2 mL.

(c). Determination of permanent hardness:

1L of same hard water sample is boiled to 1/4th of its volume. All bicarbonates are converted to insoluble carbonates. It is filtered and made to one litre. 50mL of this water sample pipette into a conical flask and experiment carried out as under standardization. Let the volume of EDTA be V_3 mL.

Formulae for Estimation of Hardness of Water by EDTA Method

STEP 1 - PREPARATION OF STANDARD HARD WATER

$$\text{Molarity(M}_1\text{) of Standard Hard H}_2\text{O solution} = \frac{\text{wt. of CaCO}_3}{\text{M.wt. of CaCO}_3} \times \frac{1000}{\text{Vml}} = \text{----- M}$$

STEP 2 – STANDARDIZATION OF EDTA

- Molarity of EDTA solution (M_2): $\frac{V_1 M_1}{V_2 n_1} = \frac{M_2}{n_2}$

$$M_2 = \frac{V_1 M_1}{V_2} = - M$$

M_1 = Molarity of standard hard water

V_1 = Volume of standard hard water

M₂= Molarity of EDTA

V_2 = Volume of EDTA

n_1 & n_2 are no. of moles of Ca^{+2} / Mg^{+2} & EDTA = 1 each

STEP 3 –ESTIMATION OF TOTAL HARDNESS OF WATER

Molarity of Hard water sample (M_3):

$$\frac{V_2 M_2}{n_2} = \frac{V_3 M_3}{n_3}$$

M_2 = Molarity of EDTA

V_2 = Volume of EDTA

$$M_3 = \frac{V_2 M_2}{V_3} = M$$

V_3 = volume of Hard water sample

M_3 = Molarity of Hard water sample

n_3 & n_2 are no. of moles of Ca^{+2} / Mg^{+2} & EDTA = 1 each

STEP 4 - Permanent Hardness Of Water :

$$\frac{V_2 M_2}{n_2} = \frac{V_4 M_4}{n_4}$$

M_2 = Molarity of EDTA

V_2 = Volume of EDTA

$$M_4 = \frac{V_2 M_2}{V_4} = M$$

V_4 = volume of Hard water sample AFTER BOILING

M_4 = Molarity of Hard water sample AFTER BOILING

n_4 & n_2 are no. of moles of Ca^{+2} / Mg^{+2} and EDTA = 1 each

Total Hardness Of Water

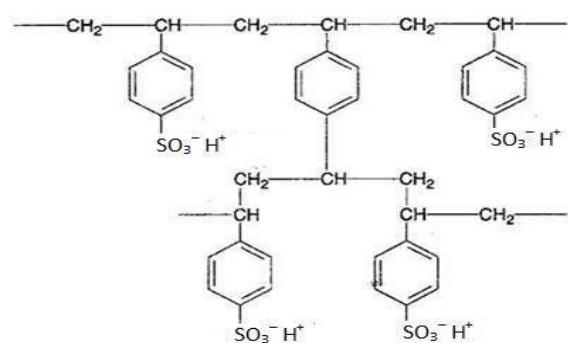
$$= M_3 \times 100 \times 1000 \text{ mg/L or ppm}$$

Permanent Hardness Of the Water Sample = $M_4 \times 100 \times 1000 \text{ ppm}$

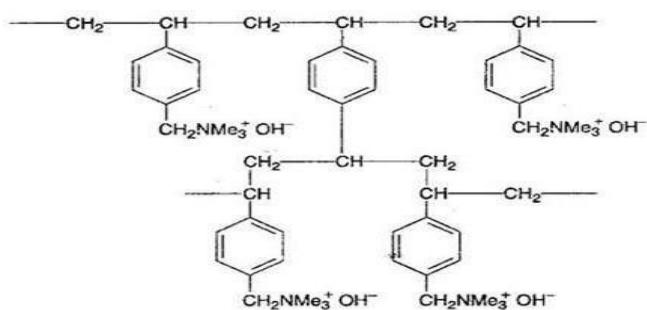
Temporary Hardness Of the Water Sample = (Total Hardness – Permanent Hardness)

$$= (M_3 \times 100 \times 1000 - M_4 \times 100 \times 1000) \text{ ppm}$$

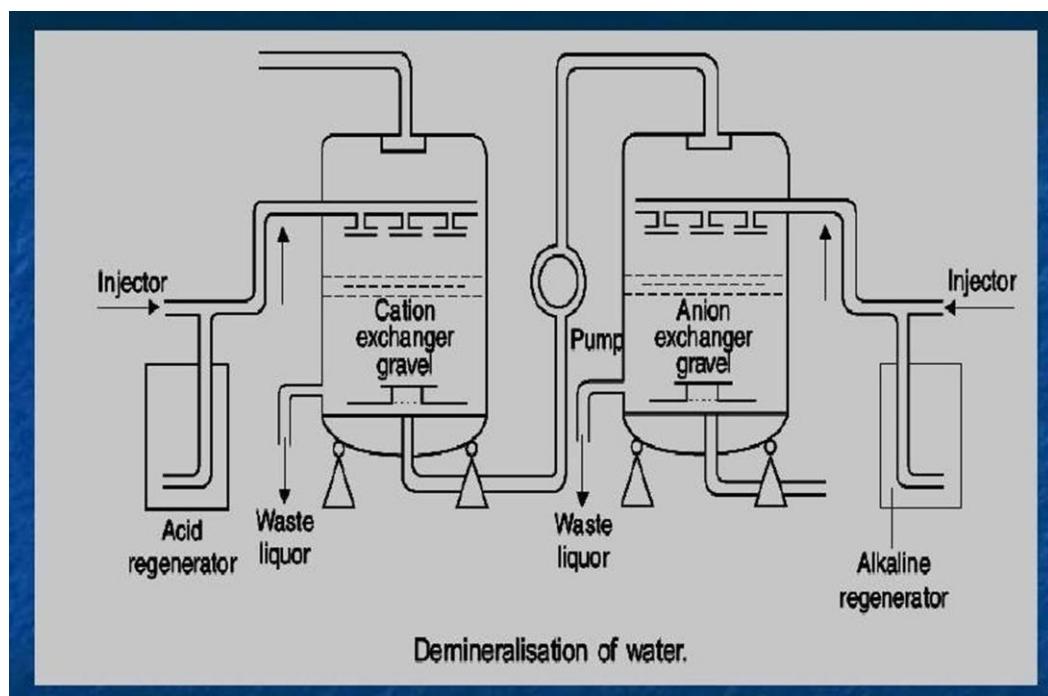
92.	Calculate temporary and permanent hardness in the following water sample containing $\text{Ca}(\text{HCO}_3)_2 = 10.5 \text{ ppm}$, $\text{Mg}(\text{HCO}_3)_2 = 12.5 \text{ ppm}$, $\text{CaSO}_4 = 7.5 \text{ ppm}$, $\text{CaCl}_2 = 8.2 \text{ ppm}$, $\text{MgSO}_4 = 2.6 \text{ ppm}$.	CO2	BTL2
93.	<p>Explain Ion – exchange method for softening of water</p> <p>Softening of water by ionexchange method: This method is also known as de-mineralization process.</p> <p>Principle: When a sample of water containing different salts (Electrolytes) come in contact with anion-exchange resin, the ions of same sign are exchanged between the resin and the water sample.</p> <p>The ion-exchange resins are insoluble, porous; cross linked polymeric materials (generally these are co-polymers of styrene and di-vinyl benzene). The functional groups attached to the chains of the polymers are responsible for ion-exchange properties.</p> <p>Ionexchangeresins areoftwotypes;</p> <p>1. Cationexchangeresins: Itconsistsoffixedanions(SO_4^{2-}, COO^-)andexchangeablecations(H^+ions).</p>	CO2	BTL3



2. Anionexchangersins:



It consists of fixed cations (N^+R_3)



ION EXCHANGE PROCESS/DETERMINERALISATION PROCESS

Ion exchange resins are insoluble, cross-linked, long chain organic polymers.
The functional groups attached to the chains can exchange hardness producing cat-ions and an-ions present in the water.

PROCESS: The process involves the following steps:

- 1) The first chamber is packed with cat-ion exchange resin (RH^+). When the hard water is passed through a bed of cation exchange resin it exchanges H^+ with Ca^{2+} , Mg^{2+} , K^+ , Na^+ etc of hard water.



Thus, the hardness producing cations (Ca^{2+} , Mg^{2+} etc) are removed

- 1) The second chamber is packed with anion exchange resin. The water coming out of the first chamber contains H^+ , Cl^- , SO_4^{2-} and HCO_3^- ions. It is now passed through anion exchange resin bed which can exchange OH^- ions with anions like Cl^- , SO_4^{2-} and HCO_3^-



Thus, hardness producing anions like Cl^- , SO_4^{2-} and HCO_3^- are removed.

- 3) Thus, H^+ ions produced from first chamber combine with OH^- ions produced from second chamber to form water.



Hence, the water produced from ion-exchange process is completely free from all cations and anions of salts.

Regeneration of resins:

When resins get saturated they need to be regenerated. The cation exchange resin is regenerated by using dil. HCl, whereas anion exchange resin is regenerated by dil. NaOH.

Advantages:

1. This method is capable of reducing hardness to almost zero.
2. It can be used to soften acidic/alkaline water.

Disadvantages:

1. This method is expensive.
2. It can't remove organic impurities and colloidal impurities.

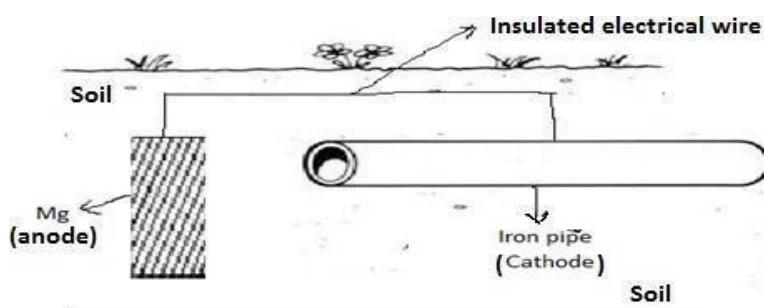
94. What is cathodic protection? Explain sacrificial anode method of protecting corrosion.	CO3	BTL3
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Cathodic protection:

The principle involved in this method is to force the metal to be protected (Parent metal) to behave like cathode. Therefore, corrosion of the parent metal is prevented. There are two types of cathodic protections, (a) Sacrificial anodic protection (b) Impressed current cathodic protection.

Sacrificial anode method

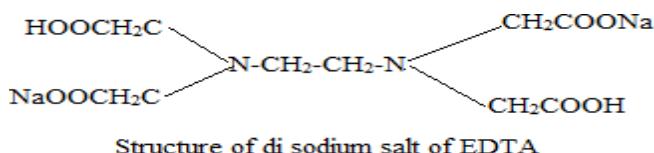
In this method, the metallic structure to be protected is electrically connected to a more active or anodic metal than the metallic structure to be protected. The more active metal acts as anode and gets corroded slowly; while the parent structure (metallic structure to be protected) is forced to act as cathode of galvanic cell, hence protected. As this more active metal is sacrificed its life in the process of saving metallic structure from corrosion, it is known as a sacrificial anode and, therefore, this method is called as sacrificial anodic protection.



95.	What is hardness of water? Describe the complexometric method using EDTA for the determination of hardness of water.	CO2	BTL3
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Hardness of Water: Hardness of water is “the characteristic that prevents lathering of soap”. (Or) It is defined as “the soap consuming capacity of water”.
Cause of Hardness: Hardness of water is caused by the presence of certain soluble salts of Ca, Mg, and salts of some other heavy metals

I. Principle: Hardness of water is estimated by a complexometric titration which involves EDTA (Ethylene Diamine Acetic Acid) as a complexing agent. EDTA forms 1:1 stable, colourless complexes with $\text{Ca}^{+2}/\text{Mg}^{+2}$ ions at pH = 9 -10.



In this titration, Eriochrome Black-T (EBT) is used as indicator which shows blue colour in its free state. When EBT is added to Hard water sample buffered to pH = 10, the water sample turns to wine-red colour due to the formation of unstable $[\text{Ca-EBT}/\text{Mg-EBT}]$ complex.



During titration, EDTA first combines with freely available $\text{Ca}^{+2}/\text{Mg}^{+2}$ ions of sample water to form stable and colourless $[\text{Ca-EDTA}/\text{Mg-EDTA}]$ complex and when all freely available $\text{Ca}^{+2}/\text{Mg}^{+2}$ ions are complexed with EDTA; further added EDTA displaces EBT from $[\text{Ca-EBT}/\text{Mg-EBT}]$ complex. Thus, at the end point the colour of the solution changes from wine red to blue.

Experimental procedure:

(a). Standardization of EDTA:

50mL of standard hard water is taken in a clean conical flask, 10mL of buffer and 2 or 3 drops EBT indicator is added to it. The colour of the solution changes to wine red. This solution titrated against EDTA solution taken in burette till the colour changes to blue. Let the volume of EDTA consumed be V_1 mL.

(b). Determination of Total Hardness:

50mL of hard water sample is taken in a conical flask and the procedure carried out as under standardization. Let the volume of EDTA consumed be V_2 mL.

(c). Determination of permanent hardness:

1L of same hard water sample is boiled to $1/4^{\text{th}}$ of its volume. All bicarbonates are converted to insoluble carbonates. It is filtered and made to one litre. 50mL of this water sample pipette into a conical flask and experiment carried out as under standardization. Let the volume of EDTA be V_3 mL.

Formulae for Estimation of Hardness of Water by EDTA Method

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STEP 2 – STANDARDIZATION OF EDTA

- Molarity of EDTA solution (M₂): $\frac{V_1 M_1}{n_1} = \frac{V_2 M_2}{n_2}$

M₁= Molarity of standard hard water

V₁= Volume of standard hard water

M₂= Molarity of EDTA

V₂= Volume of EDTA

$$M_2 = \frac{V_1 M_1}{V_2} = M$$

n₁ & n₂ are no. of moles of Ca⁺² / Mg⁺² & EDTA = 1 each

STEP 3 –ESTIMATION OF TOTAL HARDNESS OF WATER

Molarity of Hard water sample (M₃):

$$\frac{V_2 M_2}{n_2} = \frac{V_3 M_3}{n_3}$$

M₂= Molarity of EDTA

V₂= Volume of EDTA

$$M_3 = \frac{V_2 M_2}{V_3} = M$$

V₃= volume of Hard water sample

M₃= Molarity of Hard water sample

n₃ & n₂ are no. of moles of Ca⁺² / Mg⁺² & EDTA = 1 each

STEP 4 - Permanent Hardness Of Water :

$$\frac{V_2 M_2}{n_2} = \frac{V_4 M_4}{n_4}$$

M₂= Molarity of EDTA

V₂= Volume of EDTA

$$M_4 = \frac{V_2 M_2}{V_4} = M$$

V₄= volume of Hard water sample AFTER BOILING

M₄= Molarity of Hard water sample AFTER BOILING

n₄& n₂ are no. of moles of Ca⁺² / Mg⁺² and EDTA = 1 each

$$\text{Total Hardness Of Water} = M_3 \times 100 \times 1000 \text{ mg/L or ppm}$$

$$\text{Permanent Hardness Of the Water Sample} = M_4 \times 100 \times 1000 \text{ ppm}$$

$$\begin{aligned} \text{Temporary Hardness Of the Water Sample} &= (\text{Total Hardness} - \text{Permanent Hardness}) \\ &= (M_3 \times 100 \times 1000 - M_4 \times 100 \times 1000) \text{ ppm} \end{aligned}$$

96.	What is corrosion of metals? Describe the mechanism of electrochemical corrosion by a) Hydrogen evolution and b) Oxygen absorption	CO3	BTL3
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Corrosion of Metals:

Corrosion is a process of gradual deterioration or destruction of metals or alloys from its surface due to unwanted chemical or electrochemical interaction of metal with its environment.

Examples:

- Formation of a layer of reddish brown scale of hydrated ferric oxide on the surface of iron.
- Formation of a green film of basic carbonate $[CuCO_3 \cdot Cu(OH)_2]$ on the surface of Copper

Wet or Electrochemical corrosion:

Wet or electrochemical corrosion is common type of corrosion which occurs under wet or moist conditions. It is observed when (i) a metal is in contact with a conducting liquid, and/or (ii) dissimilar metals are dipped partially in aqueous corrosive environment.

Case I: Evolution of H_2

At anode:



At cathode:

The hydrogen ions (H^+) are formed due to the acidic environment and the following reaction occurs in absence of oxygen

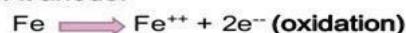


The overall reaction is $Fe + 2H^+ \longrightarrow Fe^{+2} + H_2$

Case II: Absorption of O_2

This type of corrosion takes place in neutral or basic medium in the presence of oxygen. The oxide of iron covers the surface of the iron. The small scratch on the surface creates small anodic area and rest of the surface acts as cathodic area

At anode:



At cathode:



97.	What is the principle involved in Cathodic protection? Discuss the two types of cathodic protection.	CO3	BTL3
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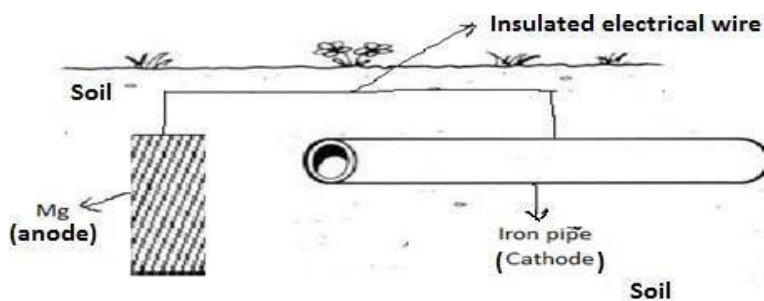
Cathodic protection:

The principle involved in this method is to force the metal to be protected (Parent metal) to behave like cathode. Therefore, corrosion of the parent metal is

prevented. There are two types of cathodic protections, (a) Sacrificial anodic protection (b) Impressed current cathodic protection.

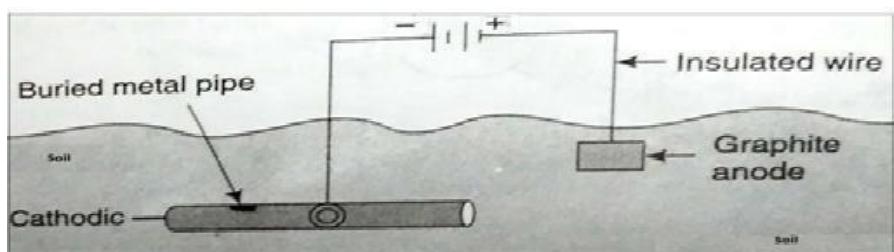
sacrificial anode method

In this method, the metallic structure to be protected is electrically connected to a more active or anodic metal than the metallic structure to be protected. The more active metal acts as anode and gets corroded slowly; while the parent structure (metallic structure to be protected) is forced to act as cathode of galvanic cell, hence protected. As this more active metal is sacrificed its life in the process of saving metallic structure from corrosion, it is known as a sacrificial anode and, therefore, this method is called as sacrificial anodic protection.



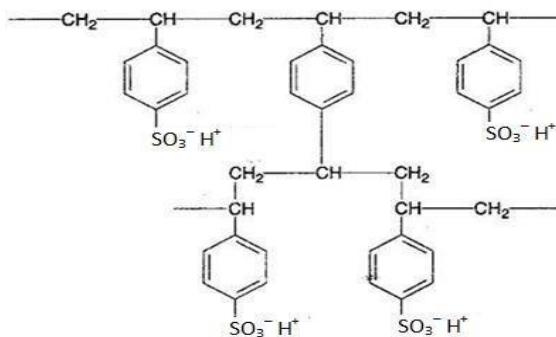
a) Impressed current cathodic protection

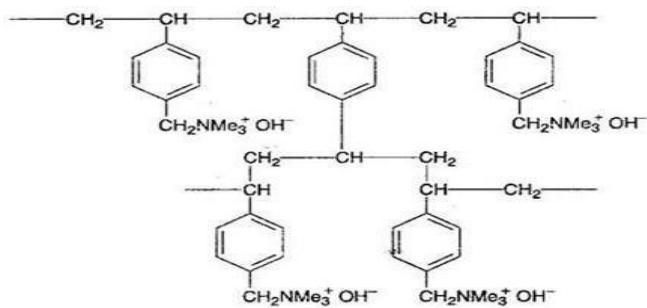
In this method, an impressed D.C current is applied, through D.C current source by a battery, between the metallic structure to be protected which is forced to act as cathode and an insoluble electrode like platinum, graphite or nickel which is buried in conducting medium adjacent to the metallic structure to be protected and acts as anode of an electrolytic cell as shown in the figure. The impressed D.C current applied nullifies the corrosion current thus the metallic structure is protected from corrosion.



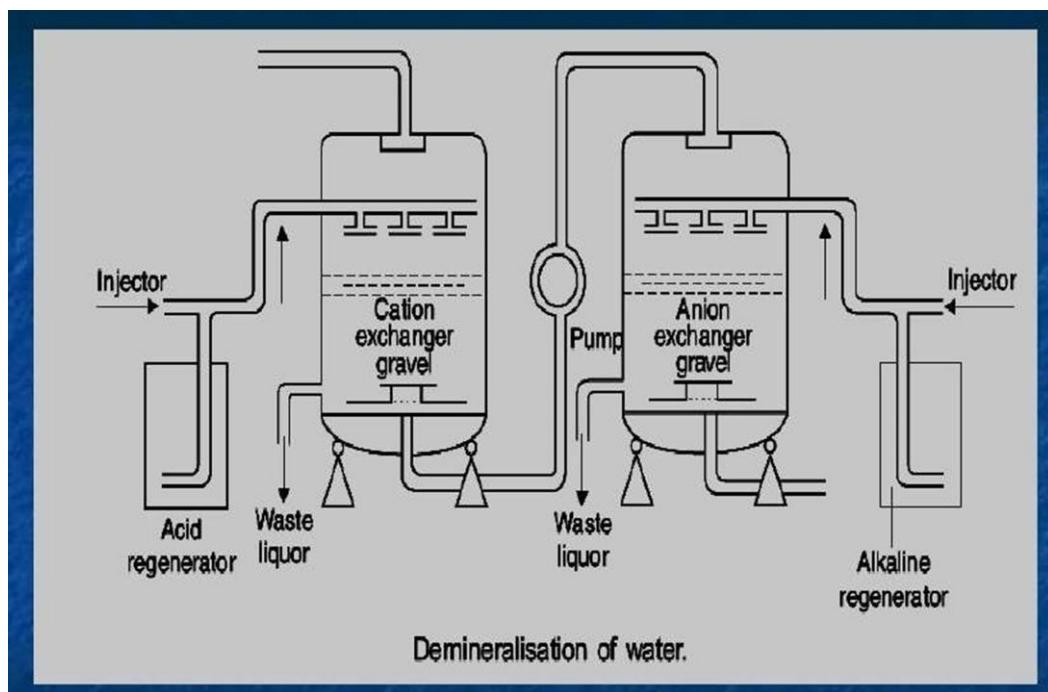
The metals which are commonly used as insoluble anodes are Graphite, Scrap iron, etc. This type of cathodic protection is applied to buried structures such as tanks and pipelines, since, their operating and maintenance costs are less, and they are well suited for large structures and long term operations.

98.	<p>a) What are the disadvantages of hard water? Explain the methods of removal of hardness of water by Ion – Exchange method.</p> <p>b) 50 ml of sample water consumed 20 ml of EDTA before boiling</p>	CO2	BTL3
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	and 5 ml of the same EDTA after boiling. Calculate the total, permanent and temporary hardness.	CO ₂	
	<p>a) <u>DISADVANTAGES OF HARDWATER / CAUSES OF HARDNESS:</u> The following are the disadvantages when hard water is used for various purpose:</p> <p>(i) <u>DOMESTIC USE:</u></p> <p>(a) <u>Washing and Bathing</u>: Hard water does not form lather easily with soap is wasted (b) <u>Drinking</u> : Hard water causes bad effects on our digestive system. Sometimes, stone formation takes place in kidneys</p> <p>(c) <u>Cooking</u> : The boiling point of water is increased due to the presence of salts. Hence, more fuel and timeare required for cooking.</p> <p>(c) <u>Textile Industry</u> : Hard water causes wastage of soap. Precipitates of calcium and magnesiumsoap adhere to the fabrics and cause problem</p> <p>(d) <u>Paper Industry</u> : Calcium and Magnesium salts in water may effect the quality of paper.</p> <p>(e) <u>Sugar Industry</u> : Water containing sulphates, carbonates, nitrates (f) affects the crystallisation of sugar.</p> <p>Softening of water by ionexchange method: This method is also known as de-mineralization process.</p> <p>Principle: When a sample of water containing different salts (Electrolytes) come in contact with anion-exchange resin,the ions of same sign are exchanged between the resin and the water sample.</p> <p>The ion-exchange resins are insoluble, porous; cross linked polymeric materials (generally these areco-polymers of styrene and di-vinyl benzene). The functional groups attached to the chains of thepolymersare responsiblefor ion-exchangeproperties.</p> <p>Ionexchangeresins areoftwotypes;</p> <p>3. Cationexchangeresins: Itconsistsoffixedanions(SO₃⁻,COO⁻)andexchangeablecations(H⁺ions).</p>  <p>4. Anionexchangeresins:</p>		



It consists of fixed cations (N^+R_3



ION EXCHANGE PROCESS/DETERMINERALISATION PROCESS:

Ion exchange resins are insoluble, cross-linked, long chain organic polymers.

The functional groups attached to the chains can exchange hardness producing cat-ions and an-ions present in the water

PROCESS: The process involves the following steps:

- 1) The first chamber is packed with cat-ion exchange resin (RH^+). When the hard water is passed through a bed of cation exchange resin it exchanges H^+ with Ca^+ , Mg^{2+} , K^+ , Na^+ etc of hard water.



Thus, the hardness producing cations (Ca^{2+} , Mg^{2+} etc) are removed

- 1) The second chamber is packed with anion exchange resin. The water coming out of the first chamber contains H^+ , Cl^- , SO_4^{2-} and HCO_3^- ions. It is now passed through anion exchange resin bed which can exchange OH^- ions with anions like Cl^- , SO_4^{2-} and HCO_3^-



Thus, hardness producing anions like Cl^- , SO_4^{2-} and HCO_3^- are removed.

- 3) Thus, H^+ ions produced from first chamber combine with OH^- ions produced from second chamber to form water.



Hence, the water produced from ion-exchange process is completely free from all cations and anions of salts.

Regeneration of resins:

When resins get saturated they need to be regenerated. The cation exchange resin is regenerated by using dil. HCl, whereas anion exchange resin is regenerated by dil. NaOH.

Advantages:

3. This method is capable reducing hardness to almost zero.
4. It can be used to soften acidic/alkaline water.

Disadvantages:

3. This method is expensive.
4. It can't remove organic impurities and colloidal impurities.

99.	Explain the Mechanism of Electrochemical corrosion.	CO3	BTL4
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Wet or Electrochemical corrosion:

Wet or electro chemical corrosion is common type of corrosion which occurs under wet or moist conditions. It is observed when (i) a metal is in contact with a conducting liquid , and/or
(ii) dissimilar metals are dipped partially in aqueous corrosive environment.

Case I: Evolution of H₂

At anode:
 $\text{Fe} \longrightarrow \text{Fe}^{++} + 2\text{e}^-$ (oxidation)

At cathode:
The hydrogen ions (H⁺) are formed due to the acidic environment and the following reaction occurs in absence of oxygen
 $2\text{H}^{++} + 2\text{e}^- \longrightarrow \text{H}_2 \uparrow$ (reduction)
The overall reaction is $\text{Fe} + 2\text{H}^+ \longrightarrow \text{Fe}^{+2} + \text{H}_2$

Case II: Absorption of O₂

This type of corrosion takes place in neutral or basic medium in the presence of oxygen. The oxide of iron covers the surface of the iron. The small scratch on the surface creates small anodic area and rest of the surface acts as cathodic area

At anode:
 $\text{Fe} \longrightarrow \text{Fe}^{++} + 2\text{e}^-$ (oxidation)

At cathode:
 $\text{O}_2 + \text{H}_2\text{O} + 2\text{e}^- \longrightarrow 2\text{OH}^-$ (reduction)

$\text{Fe} + \text{O}_2 + \text{H}_2\text{O} \longrightarrow \text{Fe}^{++} + 2\text{OH}^- \text{ or } \text{Fe(OH)}_2$

100.	0.5 gm of CaCO ₃ was dissolved 0.1 M HCl and diluted to 100 ml. 50 ml of this solution required 48 ml of EDTA solution. 50 ml of the same water sample on boiling, filtering required 15 ml of EDTA solution. 50 ml of same sample on boiling filtering required 10 ml of EDTA solution. Calculate temporary, permanent and total hardness of water sample.	CO2	BTL3
101.	Factors affecting rate of corrosion?	CO2	BTL3
<p>Nature of metal</p> <p>Position of the metal in Galvanic Series:</p> <p>Galvanic series gives real and useful information regarding the corrosion behaviour of metals and alloys in a given environment.</p> <p>When two metals are electrically combined and exposed to corrosive environment the metal with lower potential acts as anode and undergoes corrosion whereas the metal with higher potential acts as cathode.</p> <p>b) Purity of metal: In general higher the purity of the metal, lesser the rate of corrosion. Thus zinc of 99.95 % purity undergoes corrosion at rate of about 5000 times more compared to zinc of 99.999% purity</p> <p>c) humidity in air: Higher the humidity (moisture content) higher will be the rate of corrosion. Moisture acts as solvent for O₂, H₂S, SO₂ etc to furnish the electrolyte essential for setting corrosion cell.</p> <p>Gases like H₂S and SO₂ increase the acidity of the medium by their dissolution in water.</p> <p>Therefore, the rate of corrosion increases as humidity increases</p> <p>Nature of surface oxide film</p> <ul style="list-style-type: none"> ➤ If the corrosion product formed is stable, non-porous and strongly adherent layer it prevents further corrosion. ➤ If corrosion product formed is highly unstable the metals do not undergo corrosion. ➤ If the corrosion product formed is porous or volatile metals undergo severe corrosion. ➤ If the corrosion product is soluble in medium to which it is immersed, corrosion of the metal occurs with a faster rate 			

102.	Calculate total and temporary hardness of water if 5 g of CaCO_3 was dissolved in dil. HCl & diluted to 1000 ml. 50 ml of this solution required 48 ml of EDTA solution for titration. 50 ml of hard water sample required 15 ml of EDTA solution for titration. 50 ml of same water sample on boiling, filtering etc. required 10 ml of EDTA solution	CO2	BTL4
103.	0.5 gm of CaCO_3 was dissolved 0.1m HCl and diluted to 100 ml. 50ml of this solution required 48 ml of EDTA solution for titration. 50 m1 of same sample required 15 ml of EDTA solution. 50 ml of the same on boiling, filtering required 10 ml of EDTA solution. Calculate temporary, permanent and total hardness of water sample.	CO3	BTL4
104.	What is the difference between wet and dry corrosion?	CO3	BTL2
<div style="display: flex; align-items: center;">  <div style="margin-left: 10px;"> <p>DRY CORROSION</p> <hr/> <ul style="list-style-type: none"> • Corrosion occurs in the absence of moisture. • It involves direct attack of chemicals on the metal surface. • The process is slow. • Corrosion products are produced at the site of corrosion. • The process of corrosion is uniform. </div> <div style="margin-left: 20px;"> <p>WET CORROSION</p> <hr/> <ul style="list-style-type: none"> • Corrosion occurs in presence of conducting medium. • It involves formation of electrochemical cells. • It is a rapid process. • Corrosion occurs at anode but rust is deposited at cathode. • It depends on the size of the anodic part of metal. </div> </div>			
105.	What is chlorination? Explain in detail break point chlorination.	CO3	BTL2

5) DISINFECTION OR STERILISATION: The process of killing pathogenic bacteria and other micro-organisms is called 'Disinfection or Sterilisation'. The chemicals used for killing bacteria are called 'DISINFECTANTS'.

Disinfection by Chlorination

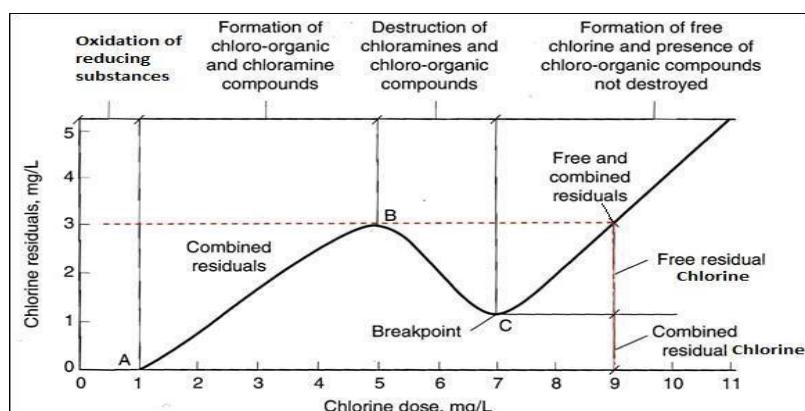
- a) **By adding Bleaching Powder:** Water is mixed with required amount of bleaching powder, and the mixture is allowed to stand for several hours



Germs + HOCl → Germs are killed

The disinfection action of bleaching powder is due to available chlorine in it. It forms hypochlorous acid which act as a powerful germicide (disinfectant)

BREAK-POINT CHLORINATION



Involves in addition of sufficient amt. of chlorine to oxidise :organic matter, reducing substances. Dosage of applied chlorine to water rich in organic compound or ammonia is gradually increased.Four stages:

- The addition of chlorine at the dip or break : 'breakpoint' chlorination. This indicates the point at which free residual chlorine begins to appear. All tastes, odour disappear at break point : water free from bad tastes and odours

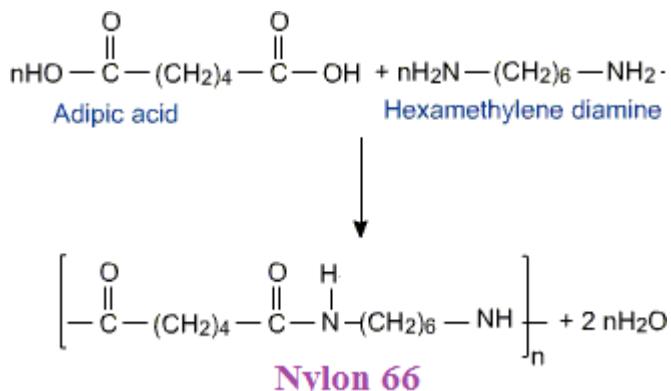
UNIT: III ENGINEERING MATERIALS			
106.	Differentiate between a) Addition polymerization from condensation polymerization. b) Monomer from polymer	CO4	BTL2
	addition polymerisation Polymerisation is polymerization. polymer Functionality of the monomer is multiple bonds like double bond which is Polymerization takes place by self addition of monomers. No byproducts formed Molecular weight is sum of molecular weights of monomers The mechanism of polymerization carried out in 3 steps ini, prop, termi Homopolymers are formed - M-M-M-M- It is Highly exothermic process as the pi bonds are converted to sigma bond An initiator is needed to start Polymer has same composition like monomer.	condensation Polymerisation Functionality of the monomer is bifunction, tri, poly like reactive Its due to slow step wise condensation of the functional Byproducts formed like H ₂ O, HCl.. Not the sum Slow step wise condensation Heteropolymers are formed. Not so much A catalyst is needed Polymer has different composition than monomer.	
	Monomers: The small individual molecules which combine with each other to form large molecules are called monomers.		
	Examples: Ethylene, vinyl chloride, styrene, etc. POLYMERS (Poly = many; Mers = Part): Polymers are high molecular weight giant molecules formed by linking together of small molecules, monomers , by means of covalent bond/chemical bond. Examples: poly ethylene, poly (vinyl chloride), Bakelite, etc.		

107.	Give the preparation, properties and Engineering applications of Nylon 6:6	CO4	BTL3
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Nylon 6:6:

Preparation: It is prepared by the condensation polymerization of adipic acid with hexamethylene diamine.

Properties:



- They are translucent, whitish, horny, high melting ($160 - 264^{\circ}\text{C}$) polymers.
- They are resistance to high temperature and abrasion.
- They are insoluble in benzene and acetone and soluble in phenol, formic acid etc.
- They have good strength and absorb little moisture.

Uses of Nylons:

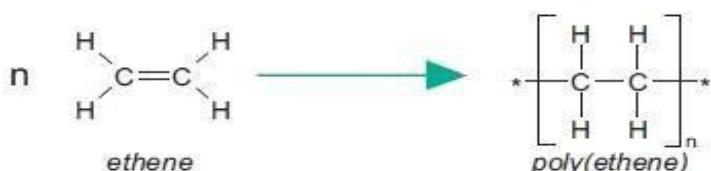
- Nylon 6:6 is used for making socks, dresses, carpets etc.
- It is also used in making gears, bearings, bushes etc.
- It is used for jacketing electrical ware and protects the electrical insulation.

108.	Define and write one example for each: a) Polymer b) Degree of polymerization. c) Co – Polymer	CO4	BTL2
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(Poly = many; Mers = Part):

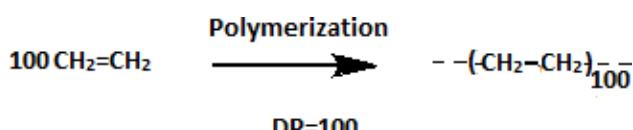
Polymers are high molecular weight giant molecules formed by linking together of smallmolecules, **monomers**, by means of covalent bond/chemical bond.

Examples: poly ethylene, poly (vinyl chloride), Bakelite, etc.



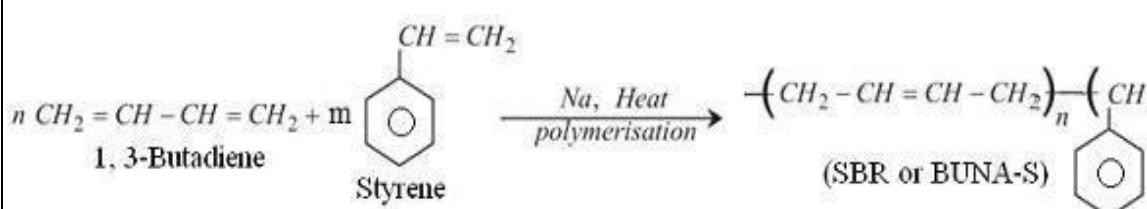
. Degree of polymerization”.

Number of monomers/repeat units present in the polymer is called “Degree of polymerization”. Example:

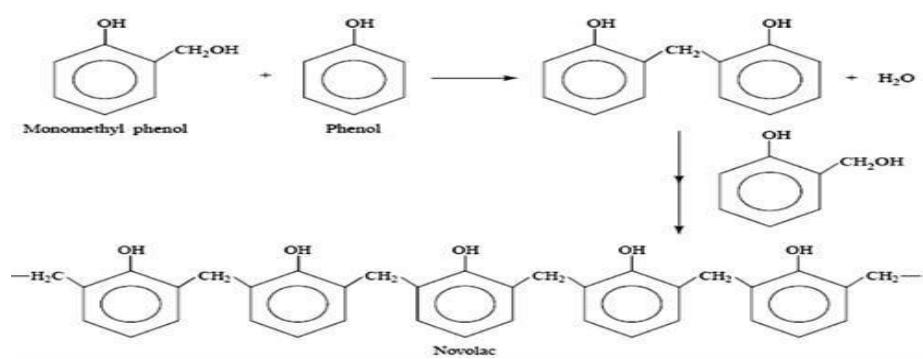


1. Co-polymerization:

- ✓ Co-polymerization is the joint polymerization of two or more monomers.
 - ✓ This is mainly to vary the properties of polymers over a wide range.Examples:

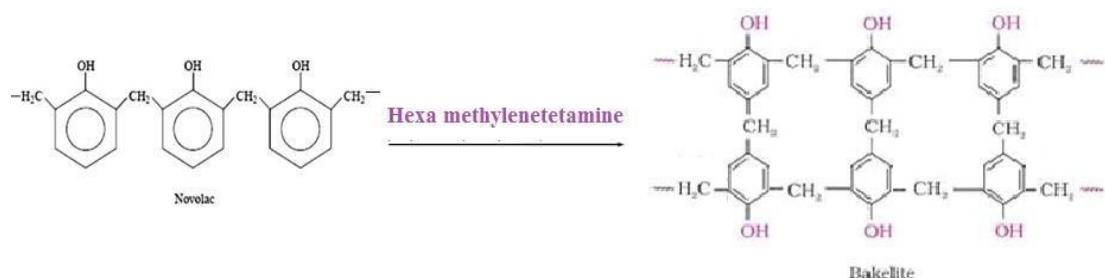


109.	Write the preparation and properties and applications of BAKELITE	CO4	BTL3
	<p>Bakelite:</p> <p>It is the condensation polymer of phenol and formaldehyde. It is also known as phenoplast and PF resin.</p> <p>Preparation: Bakelite preparation involves the following steps:</p> <p>Step (i):</p> <p>Phenol and formaldehyde react to form methylol derivatives which act as monomers for subsequent polymerization</p> <p>Step (ii): In presence of acid catalyst when mole ratio P/F>1.</p> <p>The methylol derivatives condense with phenol to form dihydroxy diphenyl methane. These on further condensation give low molecular weight linear polymers which are fusible, soluble and are known as “Novalacs”</p>		



Step (iii):

Further heating of Novolac in presence of hexamethylenetetramine [(CH₂)₆N₄] as curing agent produces a hard, rigid, insoluble and infusible 3-D cross linked polymer known as “Bakelite”.



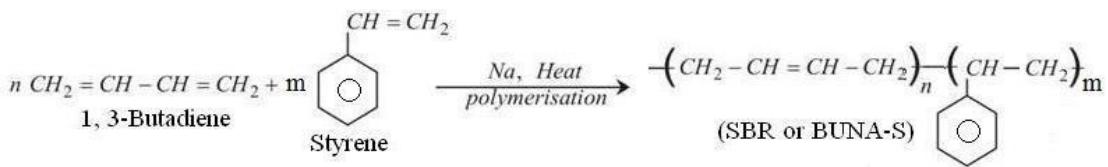
Properties:

- Bakelite is hard, infusible and insoluble strong material.
- They have excellent heat, chemical resistance, but are affected by strong caustic alkalis.
- They have good electrical insulation characteristics.

They have good abrasion resistance

- Uses:
- For making electrical insulating parts like switches, plug etc.
- For making telephone parts, cabinets for radio & television.
- In paints and varnishes.
- As ion exchange resin in softening of water by ion-exchange method

110.	Write the preparation and properties and applications of 1) BUNA – S. 2) Kevlar	CO4	BTL3
	BUNA -S SBR is a copolymer which is prepared by the co-polymerization of 1, 3-butadiene (75%) and styrene (25%)		



Properties: Buna-S has the following properties,

- High abrasion resistance and load bearing capacity.
 - Good Resilience.
 - It swells in oils and solvents.
 - It gets readily oxidized due to the presence of unsaturation.

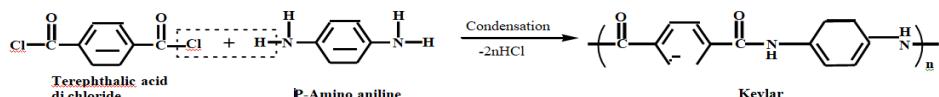
Uses: SBR is used for making,

- Automobile tyres, foot wear components.
 - Insulation for electrical wires.
 - Conveyor belt, tank lining.

Kevlar

Kevlar (Aramid) : It is a aromatic polyamide, therefore also known as **aramid**.

Preparation: It is prepared by the condensation polymerisation of terephthalic acid dichloride and 1, 4- di amino benzene (P-amino aniline).



Properties:

- It is very rigid polymer
 - Exceptionally strong (Five times stronger than steel and 10 times stronger than Al) and has high heat stability.
 - The unique properties of Kevlar are due to the benzene rings which are linked to the amide group. There are stronger inter molecular forces between neighboring chains, which make it exceptionally strong.

Uses:

- Used in tyres, brakes, clutch lining and other car parts.
 - Bullet-proof vests.
 - Motor cycle helmets.
 - Used in Aerospace and air-craft industries.

111.	Distinguish between thermoplastics and thermosetting resins.	CO4	BTL2
	Thermoplastics They soften on heating and harden on cooling reversibly.	Thermosetting polymers They are not softened on heating once set. Prolonged heating leads to charring.	
	They are formed by addition or condensation polymerization.	They are formed by condensation polymerization.	
	They have either linear or branched structures.	These have 3D cross linked structures.	

	<p>They can be recycled, re-moulded, re-shaped and re-used.</p> <p>They are soluble in some organic solvents</p> <p>They are tough & less brittle</p> <p>Ex: PE, PP, PVC, PMMA, Teflon.</p>	<p>They can't be re-cycled, re-moulded, re-shaped.</p> <p>They are insoluble in organic solvents.</p> <p>They are tough but more brittle.</p> <p>Ex: PF, UF, MF</p>	
112.	Explain preparation properties and uses of PVC and Nylon 6:6.	CO4	BTL2
	<p>Poly vinyl chloride (PVC) is obtained by heating a water emulsion of Vinyl chloride in presence of benzoyl peroxide or H_2O_2 in an auto clave under pressure.</p>		

Properties

1. Rigid PVC is a colourless, odourless and non-inflammable.
2. It has excellent oil resistance and resistance to weathering.
3. Due to the presence of 'Cl' atoms, hardness and stiffness of the polymer increases.
4. It has high chemical resistance, but soluble in ethyl chloride.

Uses of Rigid PVC: It is used for making

1. Leather cloth used for car seat, covers etc
2. Kitchen upholstery, ladies hand bags, plastic rain coats

Baby pants, swim suits etc

Nylon 6:

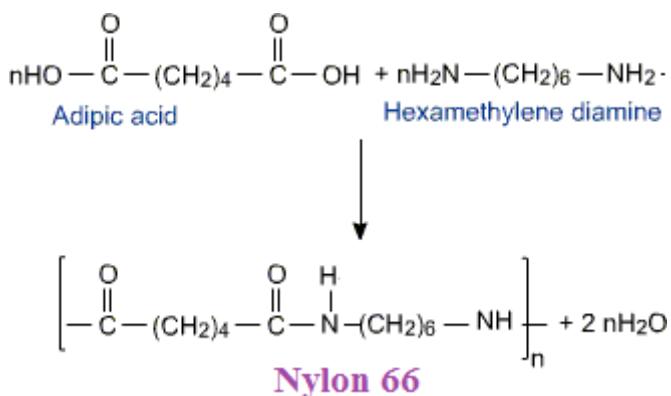
Preparation: It is prepared by the condensation polymerization of adipic acid with hexamethylene diamine.

Properties:

$$\begin{array}{ccc}
 nHO-C(=O)-(CH_2)_4-C(=O)-OH & + & nH_2N-(CH_2)_6-NH_2 \\
 \text{Adipic acid} & & \text{Hexamethylene diamine} \\
 & \downarrow & \\
 & \left[-C(=O)-(CH_2)_4-C(=O)-N(H)-\overset{\overset{O}{||}}{(CH_2)_6}-NH \right]_n & + 2nH_2O \\
 & \text{Nylon 66} &
 \end{array}$$

- They are translucent, whitish, horny, high melting ($160 - 264^\circ C$) polymers.
- They are resistance to high temperature and abrasion.
- They are insoluble in benzene and acetone and soluble in phenol, formic

	<p>acid etc.</p> <ul style="list-style-type: none"> They have good strength and absorb little moisture. <p>Uses of Nylons:</p> <ul style="list-style-type: none"> Nylon 6:6 is used for making socks, dresses, carpets etc. It is also used in making gears, bearings, bushes etc. <p>It is used for jacketing electrical ware and protects the electrical insulation</p>		
113.	What is polymerization? Explain types of polymerization with examples?	CO4	BTL-2
<p>Polymerization: The process of joining together of small molecules by means of covalent bonds to form extremely large molecule is called polymerization.</p> <p>Types of polymerization:</p> <p>1. Addition polymerization/Chain growth polymerization:</p> <ul style="list-style-type: none"> Addition polymerization is a reaction that yields a polymer which is an exact multiple of monomers, without the elimination of by-products. Monomers having double bonds such as alkenes, alkynes, undergo addition polymerization. It is induced by heat or light or catalyst. <p>Example : polyethylene</p> $n \begin{array}{c} \text{H} & & \text{H} \\ & \diagdown & / \\ & \text{C} = \text{C} \\ & / & \diagdown \\ \text{H} & & \text{H} \end{array} \rightarrow *-\left[\begin{array}{c} \text{H} & \text{H} \\ & \\ \text{C} & - & \text{C} \\ & \\ \text{H} & \text{H} \end{array}\right]_n-*$ <p style="text-align: center;"><i>poly(ethene)</i></p> <p>2. Condensation polymerization/step polymerization:</p> <ul style="list-style-type: none"> Condensation polymerization is a reaction occurring between two bi – or poly functional monomers having polar functional groups. It always accompanies with elimination of small molecules like H₂O, HCl, NH₃, etc. For example, >C=O, -COOH, -OH and -NH₂ carrying monomers undergo condensation polymerization. <p>Example : Nylon 6,6.</p>			

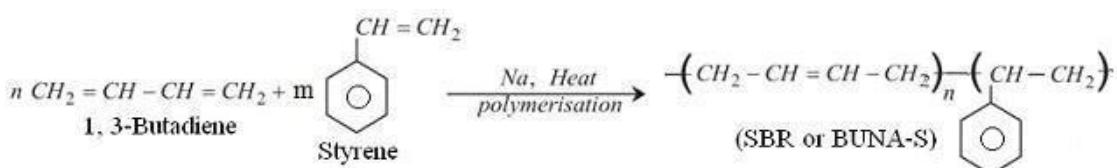


3. Co-polymerization:

- ✓ Co-polymerization is the joint polymerization of two or more monomers.
- ✓ This is mainly to vary the properties of polymers over a wide range.

Examples:

i. Buna-S (SBR)



114.	Define biodegradable polymer. Give preparation, properties and applications of poly lactic acid.	CO4	BTL3
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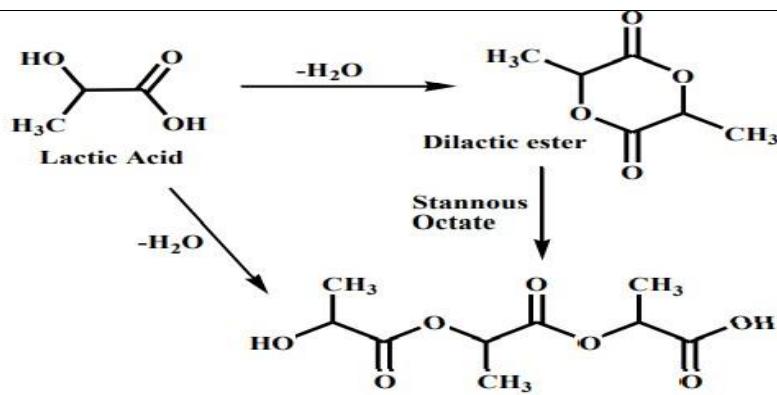
BIODEGRADABLE POLYMER:

Biodegradable polymers are defined as “the polymeric materials that undergo degradation by environmental factors like sunlight, temperature changes or by the action of micro organisms like algae, fungi and bacteria” Example: Polylactic acid.

the advantages of Biodegradable polymer.

- *They are easily compostable.*
- *It is used to produce non toxic products*
- *It is capable of maintaining good mechanical integrity until degradation*
- *It is used for packing ,agriculture, and medicines*

Polylactic acid: It is biodegradable thermo plastic, aliphatic polyester derived from renewable resources such as corn starch (in USA), Tapioca products (roots, starch, mostly in Asia) and sugar cane in rest of the world.



PROPERTIES:

Poly(lactic acid) can be processed like most thermoplastics into fibre and film.

The melting temperature of PLLA can be increased 40-50 °C and its heat deflection temperature can be increased from approximately 60°C to up to 190 °C by physically blending the polymer with PDLA (poly-D-lactide).

APPLICATIONS:

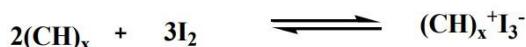
Poly (lactic acid) can be processed by extrusion, injection moulding, film & sheet casting, and spinning, providing access to a wide range of materials.

Being able to degrade into innocuous lactic acid, PLA is used as medical implants in the form of anchors, screws, plates, pins, rods, and as a mesh.

Depending on the exact type used, it breaks down inside the body within 6 months to 2 years. In the form of fibres and non-woven textiles, PLA also has many potential uses, for example as upholstery, disposable garments, awnings, feminine hygiene products, and diapers

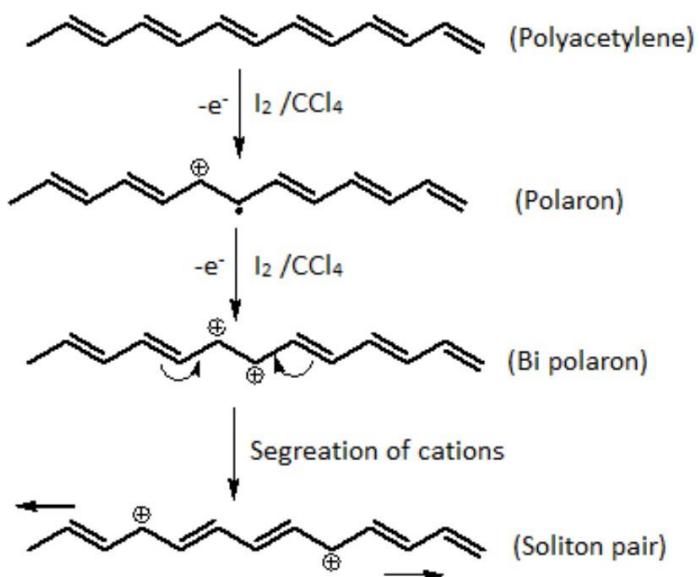
115.	Explain the mechanism of conduction in polyacetylene and write the applications of conducting polymers.	CO4	BTL3
	DOPED CONDUCTING POLYMERS: The conducting polymers with high conjugation can be easily oxidised or reduced as they have low ionisation potential. Their conductivities can be increased by creating positive or negative charge on polymer backbone by oxidation or reduction. Doping is two types:		

P-DOPING (OXIDATIVE DOPING): It is done by oxidation process. Conducting polymer having conjugation is treated with Lewis acids or I₂ vapour of I₂ in CCl₄.



P-Doping of polyacetylene:

In p-doping, conducting polymer having conjugation is partially oxidised using a suitable oxidising agent which leads to the formation of delocalised radical ion called, Polaron. A second oxidation of this Polaron, followed by radical recombination yields two positive charge carriers on each chain which are mobile. Thus, these delocalised positive charges are current carriers for conduction

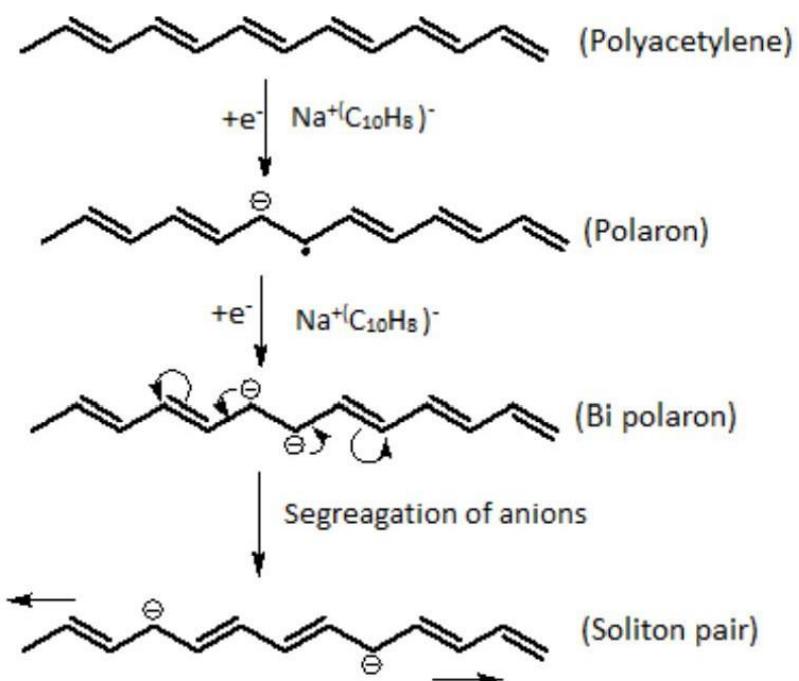


N-Doping (Reductive doping):

It is done by reduction process. Conducting polymer is treated with Lewis bases or reducing agents

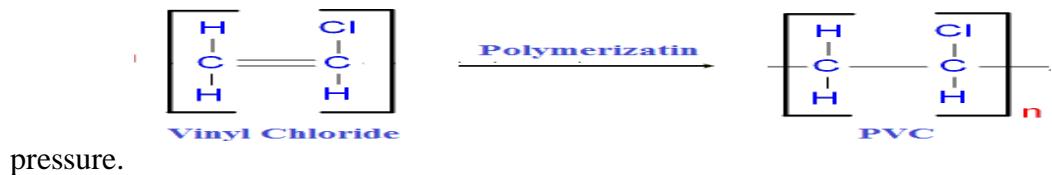


N-Doping of polyacetylene: In n-doping, the reduction process leads to formation of Polaron and bi polaron in two steps. This followed by recombination of radical ion yields two negative charge carriers on each chain of polyacetylene which are responsible for conduction.



116.	Discuss the preparation, properties and engineering applications of PVC.	CO4	BTL3
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Poly vinyl chloride (PVC) is obtained by heating a water emulsion of Vinyl chloride in presence of benzoyl peroxide or H_2O_2 in an auto clave under



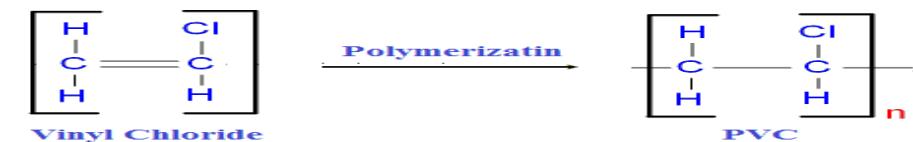
pressure.

Properties

1. Rigid PVC is a colourless, odourless and non-inflammable.
2. It has excellent oil resistance and resistance to weathering.
3. Due to the presence of 'Cl' atoms, hardness and stiffness of the polymer increases.
4. It has high chemical resistance, but soluble in ethyl chloride.

117.	preparation properties and uses of PVC and Nylon 6:6.	CO4	BTL2
------	---	-----	------

Poly vinyl chloride (PVC) is obtained by heating a water emulsion of Vinyl chloride in presence of benzoyl peroxide or H_2O_2 in an auto clave under pressure.



Properties

5. Rigid PVC is a colourless, odourless and non-inflammable.
6. It has excellent oil resistance and resistance to weathering.
7. Due to the presence of 'Cl' atoms, hardness and stiffness of the polymer increases.
8. It has high chemical resistance, but soluble in ethyl chloride.

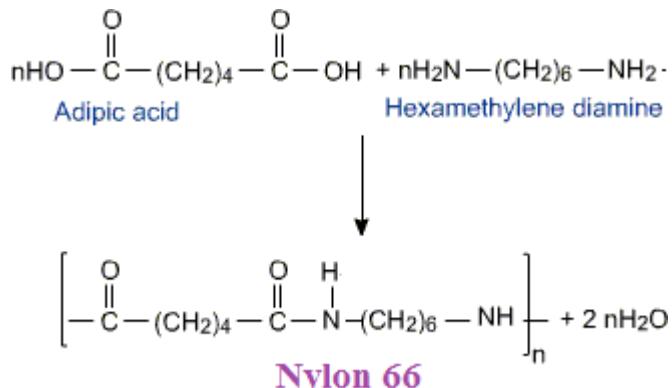
Uses of Rigid PVC: It is used for making

3. Leather cloth used for car seat, covers etc
4. Kitchen upholstery, ladies hand bags, plastic rain coats
5. Baby pants, swim suits etc.

Nylon 6:6

Preparation: It is prepared by the condensation polymerization of adipic acid with hexamethylene diamine.

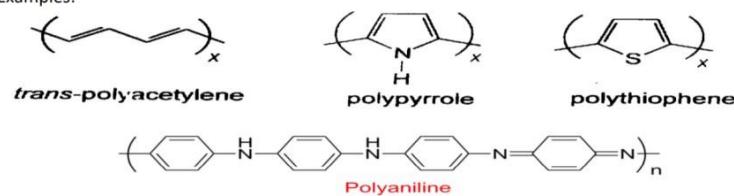
Properties:



- They are translucent, whitish, horny, high melting ($160 - 264^\circ\text{C}$) polymers.
- They are resistance to high temperature and abrasion.
- They are insoluble in benzene and acetone and soluble in phenol, formic acid etc.
- They have good strength and absorb little moisture.

Uses of Nylons:

- Nylon 6:6 is used for making socks, dresses, carpets etc.

	<ul style="list-style-type: none"> It is also used in making gears, bearings, bushes etc. <p>It is used for jacketing electrical ware and protects the electrical insulation</p>		
118.	Write a note on i) Conducting polymers ii) Biodegradable polymers.	CO4	BTL2
	<p>CONDUCTIVE POLYMER:</p> <p>The polymers which can conduct electricity due to extensive conjugation are called as conducting /conductive polymers.</p> <p>Examples:</p>  <p><i>trans</i>-polyacetylene polypyrrole polythiophene</p> <p>Polyaniline</p>		

Intrinsically conducting polymers:

These polymers have extensive conjugation in the backbone which is responsible for conductance.

a) Conducting polymers having conjugated π - electrons in the backbone:

These polymers contain conjugated π - electrons in the backbone which increases their conductivity to a large extent. This is because, overlapping of conjugated π – electrons over the entire backbone results in valance and conduction bands. These bands are separated by a significant band gap. The electrical conduction occurs only after thermal or photolytic activation of electrons to give them sufficient energy to jump the gap and reach into the lower levels of the conduction band.

b) Doped conducting polymers:

The conducting polymers with high conjugation can be easily oxidised or reduced as they have low ionisation potential. Their conductivities can be increased by creating positive or negative charge on polymer backbone by oxidation or reduction.

Doping is two types:

BIODEGRADABLE POLYMER:

	<p>Biodegradable polymers are defined as “the polymeric materials that undergo degradation by environmental factors like sunlight, temperature changes or by the action of micro organisms like algae, fungi and bacteria” Example: Polylactic acid.</p> <p>the advantages of Biodegradable polymer.</p> <ul style="list-style-type: none"> • <i>They are easily compostable.</i> • <i>It is used to produce non toxic products</i> • <i>It is capable of maintaining good mechanical integrity until degradation</i> • <i>It is used for packing ,agriculture, and medicines</i> 	
119.	Give preparation, properties and applications of poly lactic acid.	CO4 BTL3
	<p>Polylactic acid: It is biodegradable thermo plastic, aliphatic polyester derived from renewable resources such as corn starch (in USA), Tapioca products (roots, starch, mostly in Asia) and sugar cane in rest of the world.</p> <pre> graph TD LA[Lactic Acid] -- "-H2O" --> DE[Dilactic ester] DE -- "Stannous Octate" --> PLA[Polylactic Acid] LA -- "-H2O" --> PLA </pre>	

PROPERTIES:

Polylactic acid can be processed like most thermoplastics into fibre and film.

The melting temperature of PLLA can be increased 40-50 °C and its heat deflection temperature can be increased from approximately 60°C to up to 190 °C by physically blending the polymer with PDLA (poly-D-lactide).

APPLICATIONS:

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Being able to degrade into innocuous lactic acid, PLA is used as medical implants in

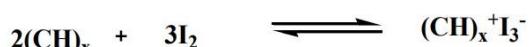
the form of anchors, screws, plates, pins, rods, and as a mesh.

Depending on the exact type used, it breaks down inside the body within 6 months to 2 years. In the form of fibres and non-woven textiles, PLA also has many potential uses, for example as upholstery, disposable garments, awnings, feminine hygiene products, and diapers

120.	Explain the mechanism of conduction in polyacetylene and write the applications of conducting polymers.	CO4	BTL3
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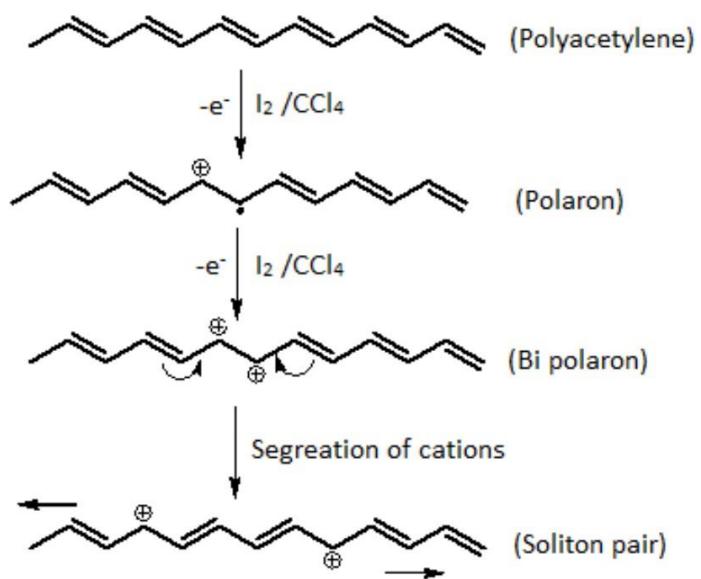
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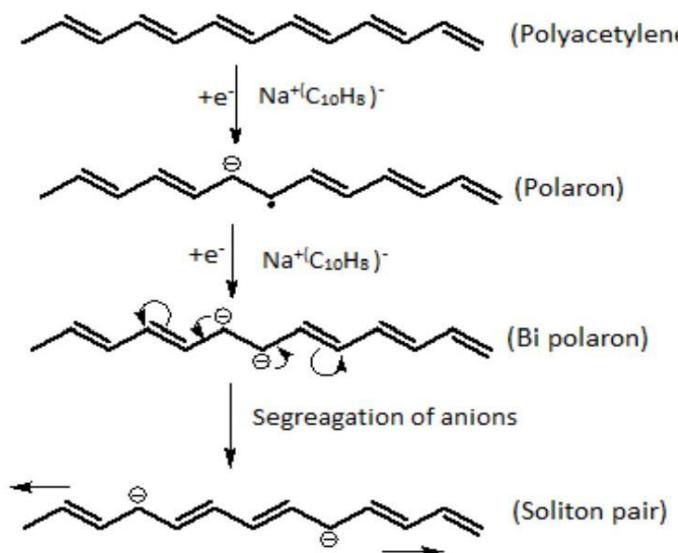


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N-Doping of polyacetylene: In n-doping, the reduction process leads to formation of Polaron and bi polaron in two steps. This followed by recombination of radical ion yields two negative charge carriers on each chain of polyacetylene which are responsible for conduction.



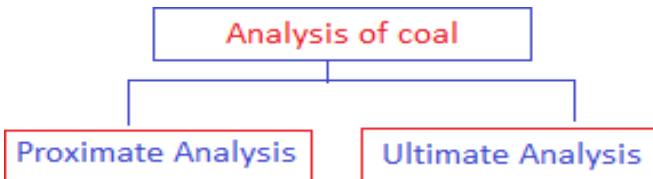
List down applications of conducting polymers

- It is used in photo voltaic devices.
- It is used as non linear optical material
- It is used in Transistors Light Emitting Diodes (LEDs)
- Lasers used in flat televisions
- Solar cells
- Electro chromic displays and optical filters
- In electronics
- In rechargeable batteries
- Displays in mobile telephones and mini-format television screens

UNIT: IV CHEMICAL FUELS

121.	Define Calorific value of a fuel. What is LPG? Give the composition, calorific value and uses of LPG.	CO5	BTL3
	<p>Calorific value: It is defined as “the total quantity of heat liberated, when a unit mass or volume of a fuel is burnt completely” in air or oxygen.</p> <p>The calorific value of a solid or liquid fuel is generally expressed in Calorie/gram (cal/g) or Kilocalorie/kg (kcal /kg) or British thermal unit /lb</p> <p>It is obtained as one of the top fractions in the fractional distillation of petroleum. It is easily liquified and so can be economically stored and transported in cylinders.</p> <p>Composition Its approximate composition is</p> <ul style="list-style-type: none"> n-Butane = 70 % Isobutane = 17 % n-Propane = 11 % Butylene and Ethane = rest. <p>Calorific Value Its Calorific Value is 27,000 kcals/m³.</p> <p>Uses</p> <ul style="list-style-type: none"> i. It is used as a fuel for domestic cooking. ii. Used for heating industrial furnaces. <p>Used as an alternate for Gasoline in automobiles.</p>		
122.	A sample of coal was found to have the following percentage composition C = 75 %, H = 5.2%, O = 12.1%, N = 3.2 % and ash = 4.5%. <ul style="list-style-type: none"> a) Calculate the minimum air required for complete combustion of 1 Kg of coal. b) Also calculate the HCV and LCV of coal sample. (Gross C.V in K. Cal / Kg, C = 8080, H = 34500, S = 2240) 	CO5	BTL3
123	Calculate the lower calorific value of fuel if the percentage of hydrogen in the fuel is 12 and HCV is – 1499 KJ,		
124.	Calculate the Gross and Net calorific values of a coal having the following compositions, C = 63 %, H = 19 %, O = 03 %, S = 13 % and ash=2. Latent heat of steam is = 587 cal/gm.	CO5	BTL3
125.	What is analysis of coal? Explain proximate analysis of coal and write its significance and importance.	CO5	BTL4
	Analysis of coal:		

The composition of coal varies widely and hence it is necessary to analyse the coal samples so that it helps to know the quality of coal.



It means finding out weight percentage of moisture, volatile matter, fixed carbon and ash in coal

Determination of moisture content in coal

About 1 gm of powdered, air dried coal sample is heated in silica crucible at 100 to 105 °C for one hour. Percentage of moisture can be calculated from the loss in weight of the coal sample as

$$\therefore \% \text{ of moisture in coal} = \frac{\text{Loss in weight of coal}}{\text{Weight of coal initially taken}} \times 100$$

Determination of Volatile Matter (V.M.) in coal

After the analysis of moisture content the crucible with residual coal sample is covered with a lid, and it is heated at 950 ± 20 °C for 7.0 minutes in a muffle furnace. Percentage of volatile matter can be calculated from the loss in weight of the coal sample as

$$\therefore \% \text{ of volatile matter in coal} = \frac{\text{Loss in weight of moisture free coal}}{\text{Weight of coal initially taken}} \times 100$$

Determination of ash in coal

After the analysis of volatile matter the crucible with residual coal sample is heated without lid at 700 ± 50 °C for 30 minutes in a muffle furnace.

Percentage of ash content can be calculated from the loss in weight of the coal sample as

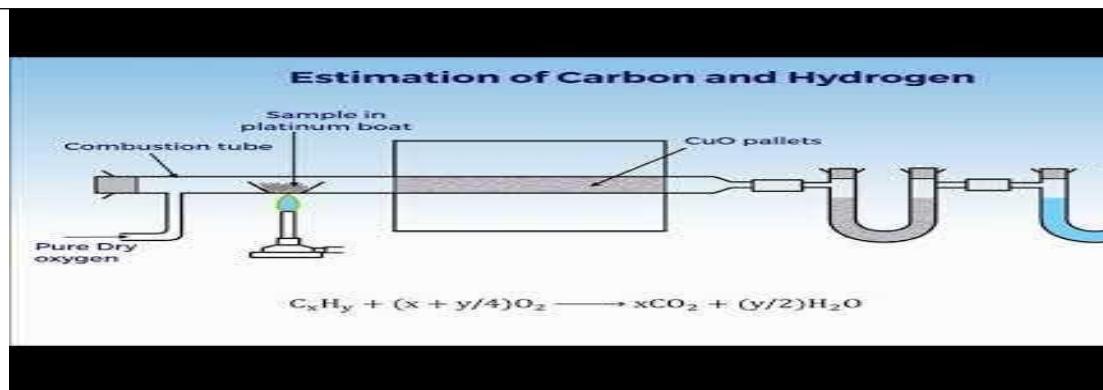
$$\therefore \% \text{ of ash in coal} = \frac{\text{Weight of ash formed}}{\text{Weight of coal taken}} \times 100$$

Determination of fixed carbon

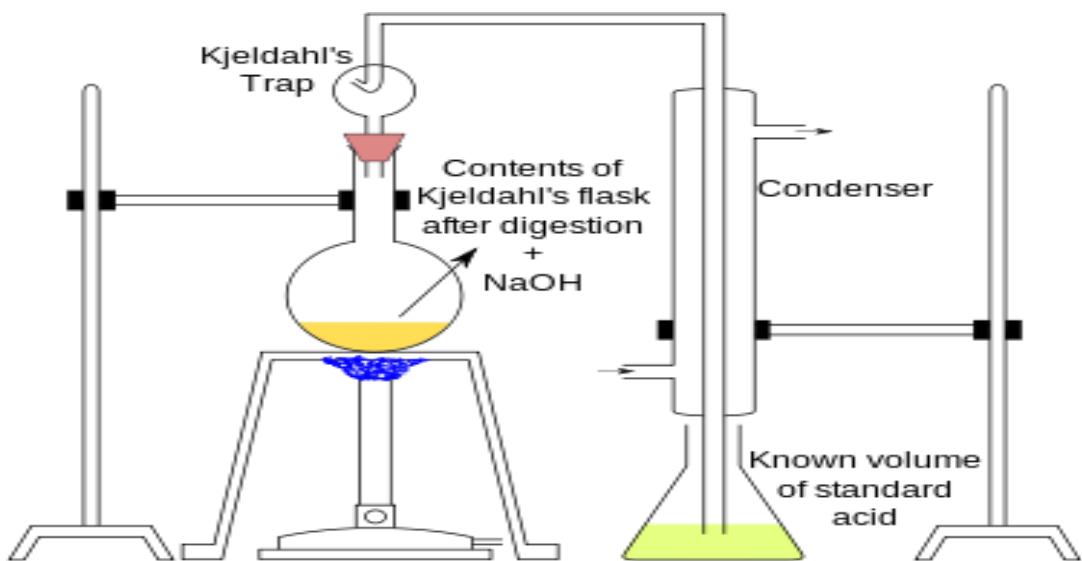
It is determined by subtracting the sum of total moisture, volatile and ash contents from 100.

$$\% \text{ of fixed carbon} = 100 - \% \text{ of [moisture + V.M + ash]}$$

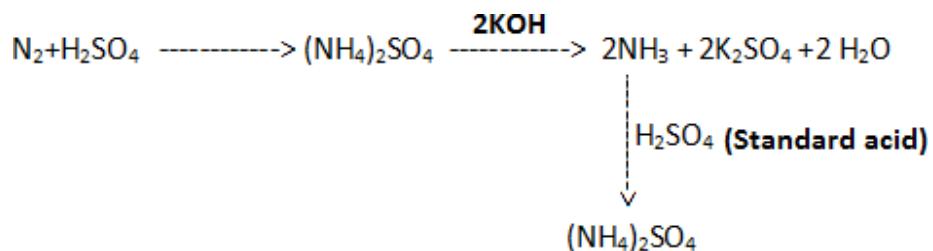
	<p>Significance (or) Importance of Proximate Analysis :</p> <p><u>MOISTURE:</u></p> <p>Moisture High moisture content in coal is undesirable because it, i) Reduces Calorific Value of coal</p> <p>Hence, lesser the moisture content, better is the quality of coal.</p> <p><u>VOLATILE MATTER:</u></p> <p>The coal with higher volatile content,</p> <p>Has lower Calorific Value Will give more quantity of coal gas when it is heated in absence of air.</p> <p><u>ASH:</u></p> <p>High ash content in coal is undesirable because it (a) increases transporting, handling, storage costs, (b) is harder and stronger, (c) has lower Caloific Value.</p> <p><u>FIXED CARBON:</u></p> <p>Fixed Carbon It is the pure carbon present in coal. Higher the fixed carbon content of the coal, higher will be its Caorific Value</p>	
126.	Explain in detail ultimate analysis of coal and write its significance.	CO5 BTL4



Determination of Nitrogen in Coal :



1 gram of accurately weighed powdered coal is digested in conc. H_2SO_4 in Kjeldahl's flask and heated. It is treated with excess of KOH when the solution becomes clear. Liberated ammonia is distilled over and absorbed in a known volume of standard solution of acid. The unused acid is determined by back titration with standard solution of NaOH.

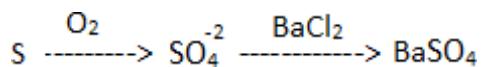


$$\% \text{ Nitrogen} = \frac{\text{Volume of acid Consumed} \times \text{Normality} \times 14}{\text{WEIGHT OF COAL SAMPLE TAKEN} \times 1000} \times 100$$

3. Determination of Sulphur:

Sulphur is determined from the washings obtained from the known mass of coal burnt in bomb

calorimeter for determination of a calorific value. During this determination, S is converted into Sulphate. The washings are treated with Barium chloride solution to convert sulphate into Barium-sulphate which is precipitate. Precipitate is filtered, washed and heated to constant weight



$$\% \text{ Sulphur} = \frac{BaSO_4 \text{ ppt formed} \times 32}{WEIGHT \text{ OF COAL SAMPLE TAKEN} \times 233} \times 100$$

Determination of Oxygen:

It is determined indirectly by subtracting the sum of percentages of carbon, hydrogen, nitrogen, sulphur and ash from 100 %

$$\% \text{ Oxygen} = 100 \% - \% \text{ of } (C + H + S + N)$$

Significance (or) Importance of Ultimate Analysis

i) Carbon and Hydrogen

Higher the % of carbon and hydrogen, better the quality of coal and higher is its calorific value.

ii) Nitrogen

1. Nitrogen does not have any calorific value, and its presence in coal is undesirable.

2. Good quality coal should have very little nitrogen content.

iii) Sulphur

Though sulphur increases the calorific value, its presence in coal is undesirable because

2. The combustion products of sulphur, i.e., SO₂ and SO₃ are harmful and have corrosion effects on equipments.

iv) Oxygen

1. Lower the % of oxygen higher is its calorific value.

2. As the oxygen content increases its moisture holding capacity increases and the calorific value of the fuel is required.

127.	Describe fractional distillation of petroleum and discuss the uses of petroleum fractions.	CO5	BTL3
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4.6.1 Refining of Petroleum (or) Crude Oil

Definition

The process of removing impurities and separating out the oil into various fractions having different boiling points is known as refining of petroleum.

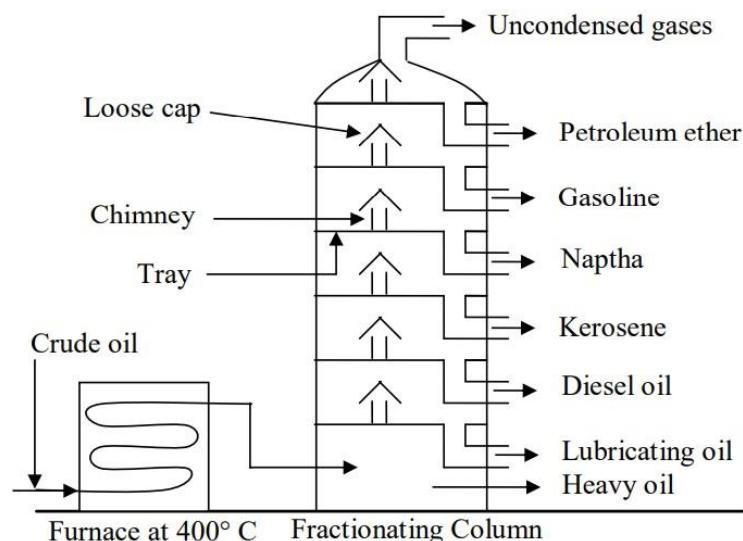


Fig 4.3! Fractional distillation of crude oil

i) Removal of Impurities

The impurities present in the oil are the fine water droplets, NaCl, MgCl₂, Sulphur etc. The crude oil is an extremely stable emulsion of oil and salt water.

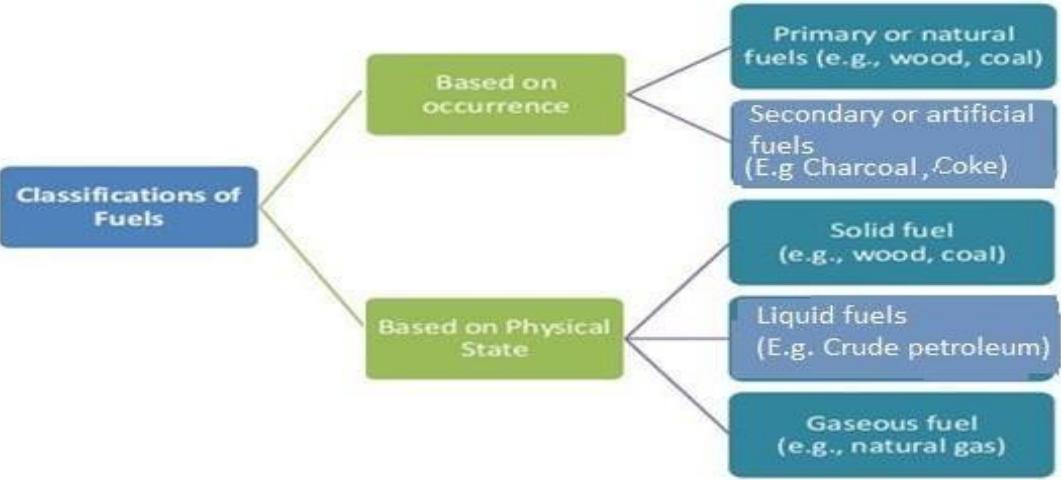
ii) Fractional Distillation

The purified crude oil is heated in a furnace called oil heater where the temperature will be around 400 C. Here the oil gets vapourised. The hot vapours are then sent to the fractionating column It is a tall cylindrical tower consisting of a number of horizontal stainless steel tray at short distances. Each tray is provided with a small chimney, which is covered with a loose cap. The tower will be hot at the lower end and comparatively cooler at the upper end. When the oil vapours go up in the tower, they become cool and condense. The heavier compounds having higher boiling points get cooled first and condensed in the trays whereas the fractions having lower boiling points condense near the top of the tower.

Table 4.2 Various fractions, Compositions and their uses

Sl.No	Name of the fraction	Boiling Range °C	Range of C-Atoms	Uses
1.	Uncondensed gases	Below 30	C1-C4	As a fuel under the name of LPG
2.	Petroleum ether	30-70	C ₅ -C ₇	As a solvent
3.	Gasoline or petrol	40-120	C ₅ -C ₉	Fuel for IC engines
4.	Naphtha or solvent spirit	120-180	C ₉ -C ₁₀	As a solvent in paints and in dry cleaning
5.	Kerosene oil	180-250	C ₁₀ -C ₁₆	Fuel for stoves and jet engines
6.	Diesel oil	250-320	C ₁₅ -C ₁₈	Diesel engine fuel
7.	Heavy oil	320-400	C ₁₇ -C ₃₀	Fuel for ships and for production of gasoline by cracking.

127.	b) Calculate the amount of air required for complete combustion of 0.5 Kg of coal.	CO5	BTL3
128.	A sample of coal was found to contain the following composition. C = 80 %, H = 5 %, S = 3.2 %, N = 2 % O = 1 % and ash = 12 %, Calculate minimum amount of air required for complete combustion of 1 kg coal sample.	CO5	BTL3
129.	Define fuel. Explain the classification and characteristics of a good fuels.	CO5	BTL2
	<p>A chemical fuel is defined as any combustible substance used to produce heat by combustion.</p> <p>A chemical process which is accompanied by evolution of heat, when a chemical fuel is subjected to burning in the presence of air or oxygen, is called as combustion</p> <p style="text-align: center;">$\text{Fuel} + \text{Oxygen} \xrightarrow{\text{combustion}} \text{Combustion products} + \text{Heat}$</p> <p>Classification of fuels:</p>		



Characteristics of good fuel:

A good fuel should satisfy the following requirements:

1. It should have a high calorific value.
2. An ideal fuel should have moderate ignition temperature.
3. Its moisture content should be low.
4. Low volatile matter content.
5. It should not produce harmful products like CO_2 , SO_2 , H_2S and other poisonous gases on combustion since they pollute the atmosphere.
6. A fuel should have low content of non-combustible matter.
7. It should be economical and easily available.

In case of solid fuel, the size should be uniform

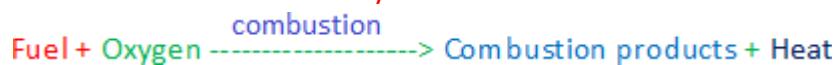
130.	An oil analysis gives the following results, C = 85 %, H = 12% and O = 3%. Find the weight of minimum air required for burning of 1Kg of fuel.	CO5	BTL3
131.	Calculate the Gross and Net calorific values of a coal having the following compositions, C = 80 %, H = 8 %, O = 8 %, S = 2 % and ash=2. Latent heat of steam is = 587 cal/gm.	CO5	BTL3
132.	a) Define fuel. Describe the requirement of good fuel. b) Calculate the amount of air required for complete combustion of 0.5 Kg of coal. A chemical fuel is defined as any combustible substance used to produce heat by combustion. A chemical process which is accompanied by evolution of heat, when a	CO5	BTL4

chemical fuel issubjected to burning in the presence of air or oxygen, is called as combustion

Characteristics of good fuel:

A good fuel should satisfy the following requirements:

1. It should have a high calorific value.
2. An ideal fuel should have moderate ignition temperature.
3. Its moisture content should be low.
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6. A fuel should have low content of non-combustible matter.
7. It should be economical and easily available.



In case of solid fuel, the size should be uniform

133.	A sample of coal contains the following by weight C = 81%, H = 4%, O = 2%, N= 10%, S= 1% and remainder ash.Calculate the volume of air required for the perfect combustion of 1 Kg of fuel assuming STP condition	CO5	BTL4
134.	b) An oil on analysis gave the following results. C = 85 %, H = 12 %, O = 3 %. Find the minimum air required for burning of 1 Kg of fuel.	CO5	BTL4
135.	The percentage composition of a sample of coal by weight was found to be C = 76%, H = 5.2% O = 12.8%, N = 2.7%, S = 1.2% and the remainder is ash. Calculate the minimum weight and volume required for complete combustion of 1 Kg of coal.	CO5	BTL3

UNIT: V GREEN CHEMISTRY

136.	What are composites? Explain the properties of composites.	CO6	BTL2
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Composite: A Composite is a material made from two or more different materials which have distinctphysical and chemical properties those individual materials that combined

The two essential constituents of composites are, 1.**Matrix phase** 2.**Dispersed phase**

3. Matrix phase:

It is a continuous body constituent of composite, enclose the composite

and gives it bulk form. The Matrix phase may be a **metal, ceramic or polymer**.

Properties :

a) It binds the fibers b) It acts as medium by transmitting & distributing the externally applied load to the dispersed phase. c) It protects the individual fibers from chemical reaction and mechanical abrasion. d) It keeps the reinforcing fibers in the proper position & orientation. e) It prevents the propagation of brittle crack

4. Dispersed phase or Reinforcement:

It is a structural constituent of composite, which determines the internal structure of composite.

Dispersed phase may be fibres, particles, flakes and whiskers.

Characteristic properties of Composite Materials:

- The composite materials show properties distinctively different from those of the individual materials of the composite.
- The composites show extraordinary combination of properties like **toughness and strength with low weights & high temperature resistance**.
- Compared to steel and aluminium, composites are **lighter, have low coefficient of thermal expansion and have superior strength, stiffness & fatigue resistance**.

They have better corrosion & oxidation-resistance

137.	a) Discuss the advantages and applications of composites b) Explain the principles of green chemistry.	CO6	BTL3
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Applications of composites:

Transportation: Composites are used in the manufacturing of automobile parts, racing vehicle components and engine parts.

Marine: They are used as propeller shafts, hulls, spars (for racing boats) etc.

Aerospace: They are used in military aircrafts, helicopters, missiles and rocket components etc.

Consumer product: They are used in sporting goods like tennis rackets, and in musical instruments etc.

Composite Applications in Building & Construction

Principles of Green Chemistry :

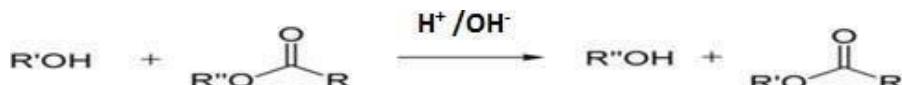
The 12 Principles of Green Chemistry are:

- 1) **Prevention** : It is better to prevent waste than to treat or clean up waste after it is formed.
- 2) **Atom Economy** : Synthetic methods should be designed to maximize the incorporation of all materials used in the process into the final product.
- 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.
- 4) **Design Safer Chemicals** : Chemical products should be designed to preserve efficacy of function while reducing toxicity. Reducing
- 5) **Safer solvents and Auxiliaries** : The use of auxiliaries substances (eg: solvents, separation agents etc) should be made unnecessary wherever possible and innocuous when used.
- 6) **Design for energy efficiency** : Energy requirements should be recognized for their environmental and economic impacts and should be minimized. Synthetic methods should be conducted at ambient temperature and pressure.
- 7) **Use of Renewable Feed stocks** : A raw material feed stock should be renewable rather than depleting whenever technically and economically practicable.
- 8) **Reduce Derivatives** : Unnecessary derivatization (use of blocking groups, protection/deprotection, temporary modification of physical/chemical process) should be avoided whenever possible.
- 9) **Catalysis** : Catalytic reagents (as selective as possible) are superior to stoichiometric reagents.
- 10) **Design for Degradation** : Chemical products should be designed so that at the end of their function they do not persist in the environment and break down into innocuous degradation products.
- 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 substance.
- 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.

138.	a) Discuss the importance of trans esterification of biodiesel and explain its significance. b) Explain any six principles of Green Chemistry.	CO6	BTL2
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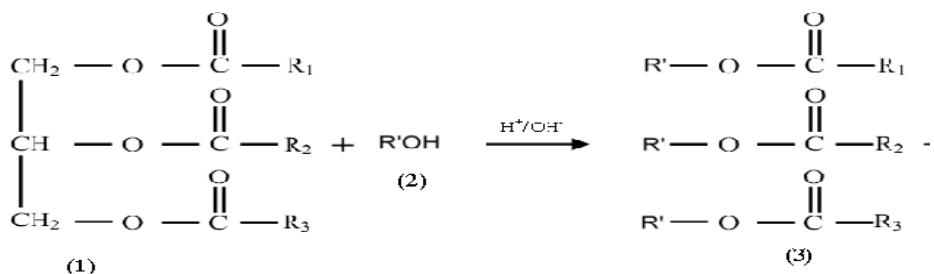
Bio diesel is produced from the seeds of Jatropha and Rape seed vegetable oils and these are not used directly as diesel fuel due to their high viscosities & high flash point. Therefore Trans – esterification of Vegetable oils is done to reduce the viscosity.

Transesterification is “the process of conversion of vegetable oils/animal oils/fats into biodiesel”.



In transesterification, the organic group R" of an ester exchanges with the organic group R' of an alcohol. These reactions are often catalyzed by an acid or base.

E.g.; Triglycerides (1) reacts with alcohols (2) to give alkyl esters (3) of a fatty acid and glycerol(4)



Base catalyzed trans esterification predominantly is used for production of biodiesel

Principles of Green Chemistry :

The 6 Principles of Green Chemistry are:

- 1. Prevention :** It is better to prevent waste than to treat or clean up waste after it is formed.
- 2. Atom Economy :** Synthetic methods should be designed to maximize the incorporation of all materials used in the process into the final product.
- 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.
- 4. Design Safer Chemicals :** Chemical products should be designed to preserve efficacy of function while reducing toxicity. Reducing
- 5. Safer solvents and Auxiliaries :** The use of auxiliaries substances (eg: solvents, separation agents etc) should be made unnecessary wherever possible and innocuous when used.
- 6. Design for energy efficiency :** Energy requirements should be recognized for their environmental and economic impacts and should be minimized. Synthetic methods should be conducted at ambient temperature and pressure.

139.	What are composite materials? Give their classification with examples.	CO6	BTL2
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Composite: A Composite is a material made from two or more different materials which have distinct physical and chemical properties those individual materials that combined

The two essential constituents of composites are, 1. **Matrix phase** 2. **Dispersed phase**

1. Matrix phase:

It is a continuous body constituent of composite, enclose the composite and gives its bulk form. The Matrix phase may be a **metal, ceramic or polymer**.

Properties :

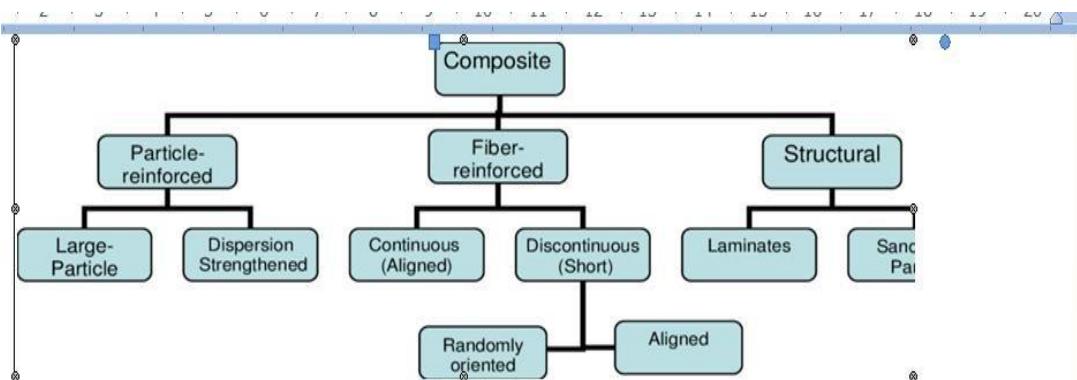
- a) It binds the fibers
- b) It acts as medium by transmitting & distributing the externally applied load to the dispersed phase.
- c) It protects the individual fibers from chemical reaction and mechanical abrasion.
- d) It keeps the reinforcing fibers in the proper position & orientation.
- e) It prevents the propagation of brittle crack

2. Dispersed phase or Reinforcement:

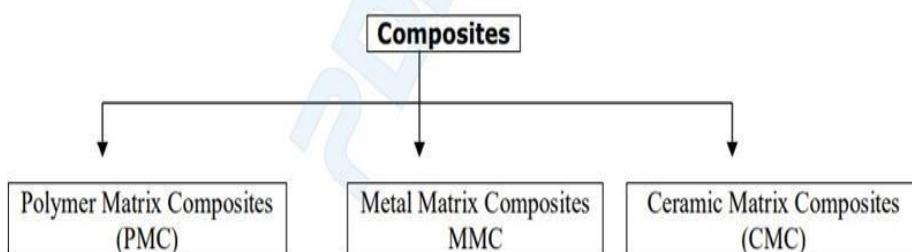
It is a structural constituent of composite, which determines the internal structure of composite.

Dispersed phase may be fibres, particles, flakes and whiskers.

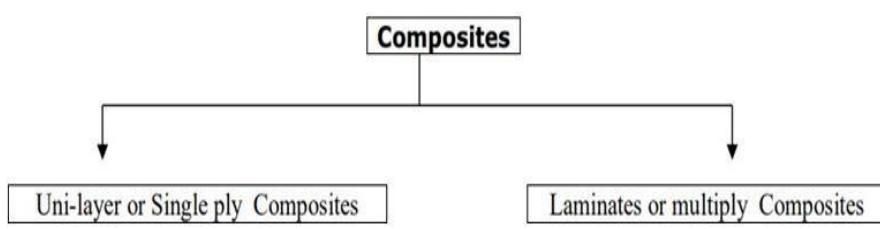
The properties of composites depend on relative amounts (i.e. Concentration), distribution and orientation of the constituent materials and geometry of the dispersed phase namely the shape, size.



(2) On the basis of type of Matrix:



(3) On the basis of number of ply or lamina's or layers:



140.	Give principle of green chemistry and explain atom economy and catalysis with examples.	CO6	BTL2
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Prevention : It is better to prevent waste than to treat or clean up waste after it is formed.

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

2. 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

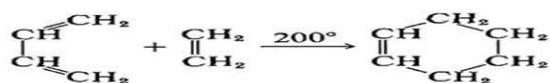
and the environment.

- 3. Design Safer Chemicals** : Chemical products should be designed to preserve efficacy of function while reducing toxicity. Reducing
- 4. Safer solvents and Auxiliaries** : The use of auxiliaries substances (eg: solvents, separation agents etc) should be made unnecessary wherever possible and innocuous when used.
- 5. Design for energy efficiency** : Energy requirements should be recognized for their environmental and economic impacts and should be minimized. Synthetic methods should be conducted at ambient temperature and pressure.
- 6. Use of Renewable Feed stocks** : A raw material feed stock should be renewable rather than depleting whenever technically and economically practicable.
- 7. Reduce Derivatives** : Unnecessary derivatization (use of blocking groups, protection/deprotection, temporary modification of physical/chemical process) should be avoided whenever possible.
- 8. Catalysis** : Catalytic reagents (as selective as possible) are superior to stoichiometric reagents.
- 9. Design for Degradation** : Chemical products should be designed so that at the end of their function they do not persist in the environment and break down into innocuous degradation products.
- 10. 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 substance.
- 11. 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.

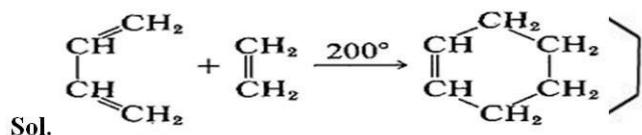
1) Atom Economy : Atom Economy is defined as the ratio of the formula weight of the target molecule to the formula weight of all the starting materials and the reagents.

$$\% \text{ Atom Economy} = \frac{\text{Mass of atoms in desired products}}{\text{Total mass of atoms in reactants}} \times 100\% .$$

1. Examples of Atom Economic reactions:



Calculate % atom economy for cyclo addition reaction of ethene and butadiene to form cyclohexene.

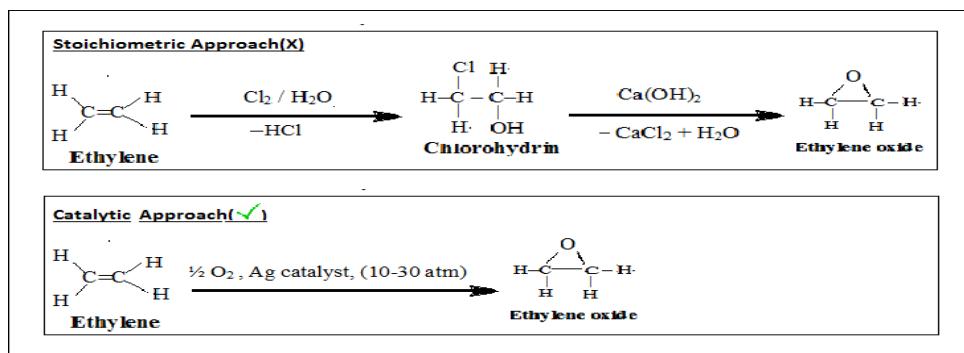


1,3-Butadiene(54) Ethene(28) Cyclo hexane(82)

$$\% \text{ Atom economy} = \frac{\text{mass of atoms in desired product}}{\text{total mass of atoms in reactants.}} \times 100$$

$$= \frac{82}{82} \times 100 = 100\%$$

Catalysis : Catalytic reagents (as selective as possible) are superior to stoichiometric reagents



141. Explain properties of matrix and reinforcement phases of composite materials with examples. CO6 BTL2

Composite: A Composite is a material made from two or more different materials which have distinct physical and chemical properties those individual materials that combined

The two essential constituents of composites are, 1. **Matrix phase** 2. **Dispersed phase**

1. Matrix phase:

It is a continuous body constituent of composite, enclose the composite and gives its bulk form. The Matrix phase may be a **metal, ceramic or polymer**.

Properties :

a) It binds the fibers b) It acts as medium by transmitting & distributing the externally applied load to the dispersed phase. c) It protects the individual fibers from chemical reaction and mechanical abrasion. d) It keeps the reinforcing fibers in the proper position & orientation. e) It prevents the propagation of brittle crack

2. Dispersed phase or Reinforcement:

It is a structural constituent of composite, which determines the internal structure of composite.

Dispersed phase may be fibres, particles, flakes and whiskers.

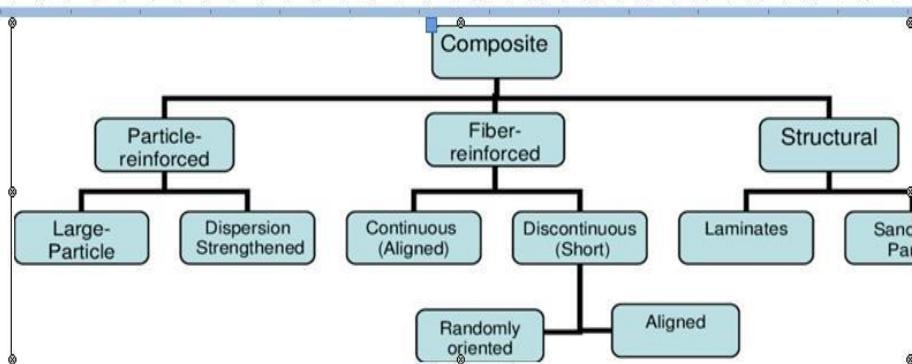
The properties of composites depend on relative amounts (i.e. Concentration), distribution and orientation of the constituent materials and geometry of the dispersed phase namely the shape, size.

Characteristic properties of Composite Materials:

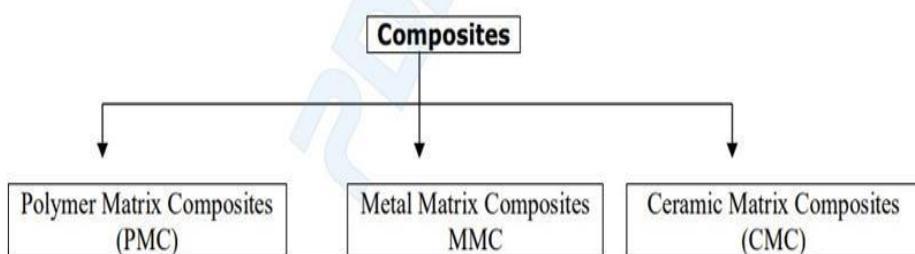
The composite materials show properties distinctively different from those of the individual materials of the composite.

The composites show extraordinary combination of properties like **toughness and strength with low weights & high temperature resistance**.

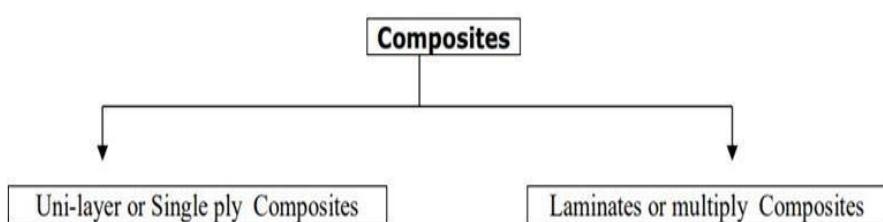
	Compared to steel and aluminium, composites are lighter, have low coefficient of thermal expansion and have superior strength, stiffness & fatigue resistance. They have better corrosion & oxidation-resistance		
142.	Explain the classification of composites based on matrix and reinforcement.	CO6	BTL2
<p>Composite: A Composite is a material made from two or more different materials which have distinct physical and chemical properties those individual materials that combined</p> <p>The two essential constituents of composites are, 1.Matrix phase 2.Dispersed phase</p> <p>1. Matrix phase: It is a continuous body constituent of composite, enclose the composite and gives it bulk form. The Matrix phase may be a metal, ceramic or polymer. Properties : a) It binds the fibers b) It acts as medium by transmitting & distributing the externally applied load to the dispersed phase. c) It protects the individual fibers from chemical reaction and mechanical abrasion. d) It keeps the reinforcing fibers in the proper position & orientation. e) It prevents the propagation of brittle crack</p> <p>2. Dispersed phase or Reinforcement: It is a structural constituent of composite, which determines the internal structure of composite. Dispersed phase may be fibres, particles, flakes and whiskers. The properties of composites depend on relative amounts (i.e. Concentration), distribution and orientation of the constituent materials and geometry of the dispersed phase namely the shape, size.</p> <p>Classification of composites:</p>			



(2) On the basis of type of Matrix:



(3) On the basis of number of ply or lamina's or layers:



143.	Explain the principle of green chemistry with examples.	CO6	BTL2
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Principles of Green Chemistry :

The 12 Principles of Green Chemistry are:

- 1) **Prevention** : It is better to prevent waste than to treat or clean up waste after it is formed.
- 2) **Atom Economy** : Synthetic methods should be designed to maximize the incorporation of all materials used in the process into the final product.
- 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.
- 4) **Design Safer Chemicals** : Chemical products should be designed to preserve efficacy of function while reducing toxicity. Reducing
- 5) **Safer solvents and Auxiliaries** : The use of auxiliaries (eg: solvents, separation agents etc) should be made unnecessary wherever possible and innocuous when used.
- 6) **Design for energy efficiency** : Energy requirements should be recognized for their

environmental and economic impacts and should be minimized. Synthetic methods should be conducted at ambient temperature and pressure.

7) Use of Renewable Feed stocks : A raw material feed stock should be renewable rather than depleting whenever technically and economically practicable.

8) Reduce Derivatives : Unnecessary derivatization (use of blocking groups, protection/deprotection, temporary modification of physical/chemical process) should be avoided whenever possible.

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

10) Design for Degradation : Chemical products should be designed so that at the end of their function they do not persist in the environment and break down into innocuous degradation products.

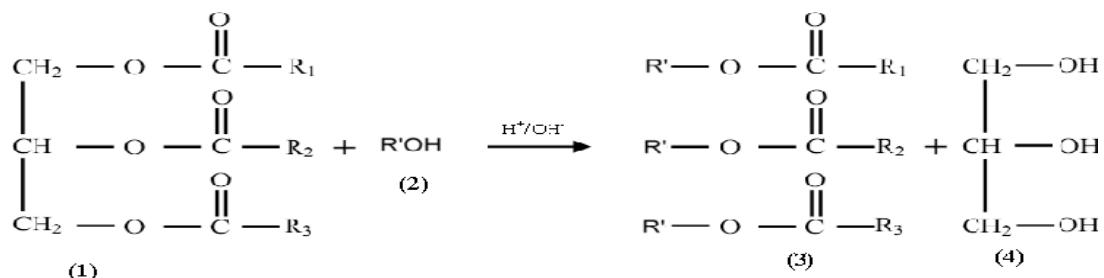
11) Real-time analysis for pollution prevention : Analytical methodologies need to be further developed to allow for real-time, in-process monitoring and control prior to the formation of hazardous substance.

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.

144.	What is Biodiesel? Discuss its importance.	CO6	BTL2
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Bio diesel is a natural and renewable domestic fuel alternative for diesel engines made from vegetable oils such as soya bean oil, palm oil, peanut oil & Sunflower seed oil. It is a green fuel and does not produce CO₂. It is nontoxic, bio degradable and free from sulphur compounds. Vegetable oils contain 90-98% triglycerides along with small quantities of mono and diglycerides, free fatty acids, phospholipids, phosphotides, carotenes etc. Triglycerides are esters of long chain fatty acids such as stearic acid, palmitic acid, linoleic acid, oleic acid. Bio diesel is produced from the seeds of Jatropha and Rape seed vegetable oils and these are not used directly as diesel fuel due to their high viscosities & high flash point. Therefore Trans – esterification of Vegetable oils is done to reduce the viscosity

Transesterification is “the process of conversion of vegetable oils/animal oils /fats into biodiesel”. In transesterification, the organic group R' of an ester exchanges with the organic group R' of an alcohol. These reactions are often catalyzed by an acid or base



Carbon neutral

Bio diesel is a Carbon neutral :

Biodiesel is said to be carbon-neutral because the carbon dioxide that is absorbed by the plants for photosynthesis process is equal to the carbon dioxide that is released when the fuel is burnt. So, there will be no net increase of CO₂ emission to the atmosphere

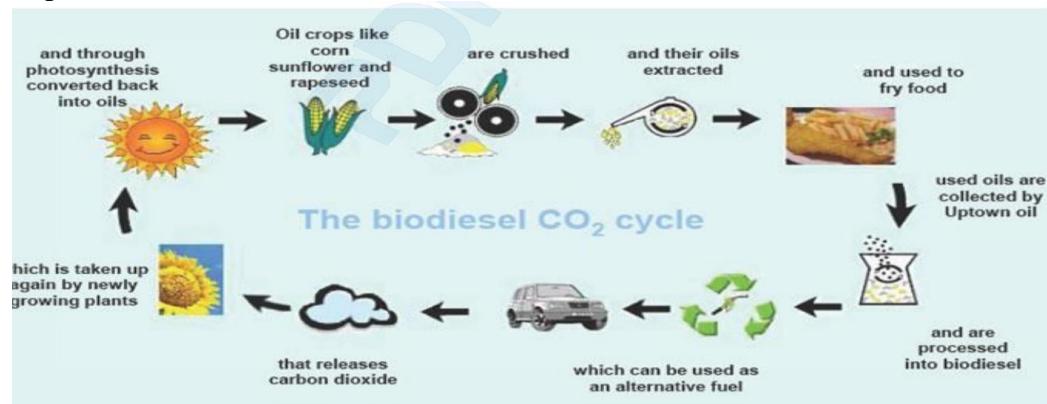
Properties of Bioiesel:

1. Biodiesel has higher cetane ratings.
2. Biodiesel has very good lubricating properties, significantly better than standard diesel which can prolong engine's life

Significance of biodiesel

3. Bio diesel is rapidly bio degradable & completely non-toxic
4. Biodiesel has shorter ignition delay

compared to standard diesel. Biodiesel has no or less sulphur content

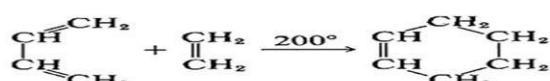


145.	Write a note on clean technology.	CO6	BTL2
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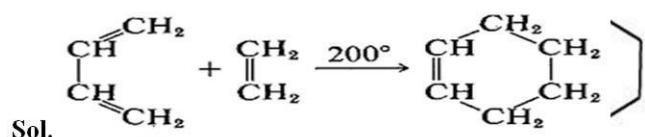
1) Atom Economy : Atom Economy is defined as the ratio of the formula weight of the target molecule to the formula weight of all the starting materials and the reagents.

$$\% \text{ Atom Economy} = \frac{\text{Mass of atoms in desired products}}{\text{Total mass of atoms in reactants}} \times 100\% .$$

1. Examples of **Atom Economic** reactions:



Calculate % atom economy for cyclo addition reaction of ethene and butadiene to form cyclohexene.



1,3-Butadiene(54) Ethene(28) Cyclo hexane(82)

$$\% \text{ Atom economy} = \frac{\text{mass of atoms in desired product}}{\text{total mass of atoms in reactants.}} \times 100$$

$$= \frac{82}{82} \times 100 = 100\%$$

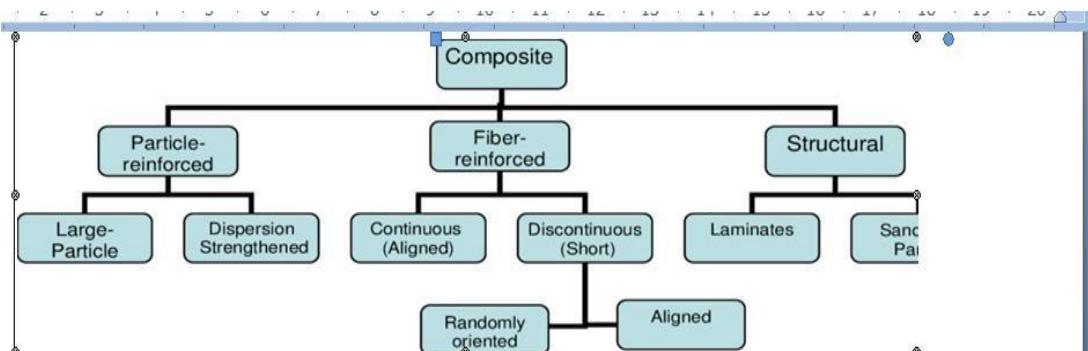
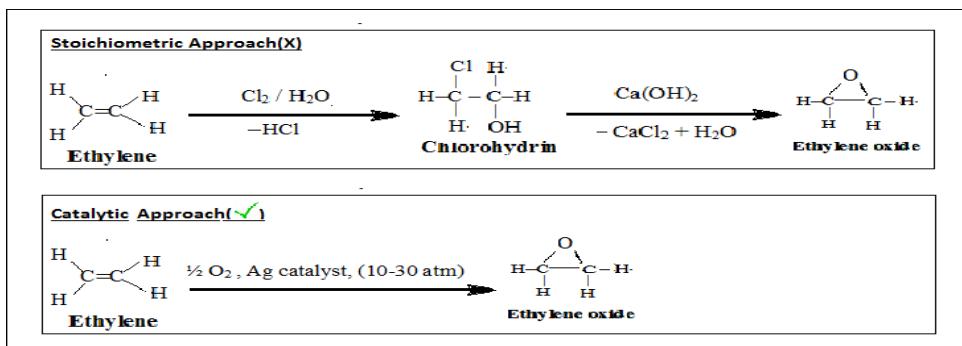
Catalysis : Catalytic reagents (as selective as possible) are superior to stoichiometric reagents

146.	<p>a) Discuss concept and principles of green chemistry. Give one example for clean technology.</p> <p>b) Explain the classification and general applications of Composites.</p>	CO6 BTL2
	<p>Prevention : It is better to prevent waste than to treat or clean up waste after it is formed.</p> <ol style="list-style-type: none"> Atom Economy : Synthetic methods should be designed to maximize the incorporation of all materials used in the process into the final product. 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. Design Safer Chemicals : Chemical products should be designed to preserve efficacy of function while reducing toxicity. Reducing Safer solvents and Auxiliaries : The use of auxiliaries substances (eg: solvents, separation agents etc) should be made unnecessary wherever possible and innocuous when used. Design for energy efficiency : Energy requirements should be recognized for their environmental and economic impacts and should be minimized. Synthetic methods should be conducted at ambient temperature and pressure. Use of Renewable Feed stocks : A raw material feed stock should be renewable rather than depleting whenever technically and economically practicable. Reduce Derivatives : Unnecessary derivatization (use of blocking groups, protection/deprotection, temporary modification of physical/chemical process) should be avoided whenever possible. Catalysis : Catalytic reagents (as selective as possible) are superior to stoichiometric reagents. <ol style="list-style-type: none"> Design for Degradation : Chemical products should be designed so that at the end of their function they do not persist in the environment and break down into innocuous degradation products. 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 substance. 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. 	

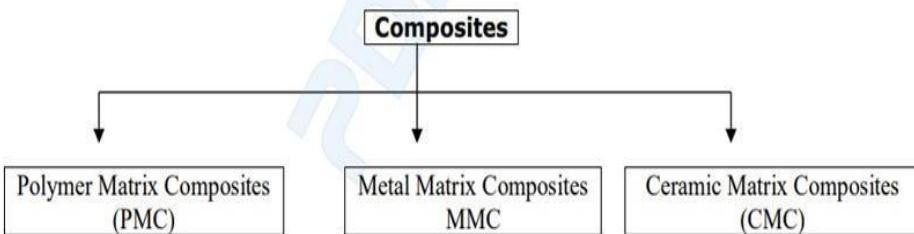
1) Atom Economy : Atom Economy is defined as the ratio of the formula weight of the target molecule to the formula weight of all the starting materials and the reagents.

$$\% \text{ Atom Economy} = \frac{\text{Mass of atoms in desired products}}{\text{Total mass of atoms in reactants}} \times 100 \%$$

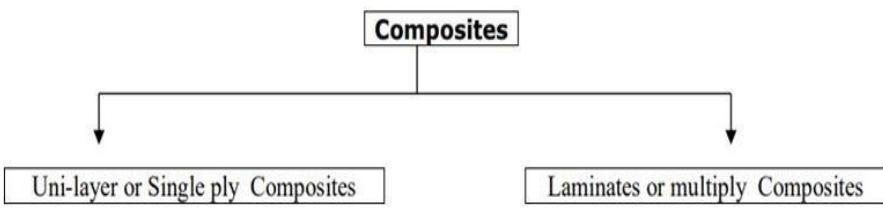
Catalysis : Catalytic reagents (as selective as possible) are superior to stoichiometric reagents



(2) On the basis of type of Matrix:



(3) On the basis of number of ply or lamina's or layers:



	<p>Applications of composites:</p> <ol style="list-style-type: none"> 1. Transportation: Composites are used in the manufacturing of automobile parts, racing vehicle components and engine parts. 2. Marine: They are used as propeller shafts, hulls, spars (for racing boats) etc. 3. Aerospace: They are used in military aircrafts, helicopters, missiles and rocket component sets. 4. Consumer product: They are used in sporting goods like tennis rackets, and in musical instruments etc. <p>Composite Applications in Building & Construction</p>		
147.	What are composites? Describe the classification of composites	CO6	BTL2
	Refer 142 answer		
148.	What are composite materials? Give their classification with examples.	CO6	BTL2
	Refer 142 answer		
149.	Explain green catalyst and atom economy with suitable examples.	CO6	BTL2
	Refer 146 answer		
150	Explain twelve principles of green chemistry	CO6	BTL2
	<p>Principles of Green Chemistry :</p> <p>The 12 Principles of Green Chemistry are:</p> <ol style="list-style-type: none"> 13) Prevention : It is better to prevent waste than to treat or clean up waste after it is formed. 14) Atom Economy : Synthetic methods should be designed to maximize the incorporation of all materials used in the process into the final product. 15) 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. 16) Design Safer Chemicals : Chemical products should be designed to preserve efficacy of function while reducing toxicity. Reducing 17) Safer solvents and Auxiliaries : The use of auxiliaries substances (eg: solvents, separation agents etc) should be made unnecessary wherever possible and innocuous when used. 18) Design for energy efficiency : Energy requirements should be recognized for their environmental and economic impacts and should be minimized. Synthetic methods should be conducted at ambient temperature and pressure. 19) Use of Renewable Feed stocks : A raw material feed stock should be renewable rather than depleting whenever technically and economically practicable. 20) Reduce Derivatives : Unnecessary derivatization (use of blocking groups, protection/deprotection, temporary modification of physical/chemical process) should be avoided whenever possible. 21) Catalysis : Catalytic reagents (as selective as possible) are superior to stoichiometric reagents. 22) Design for Degradation : Chemical products should be designed so that at the end of 		

their function they do not persist in the environment and break down into innocuous degradation products.

- 23) **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 substance.
- 24) **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.

Course Coordinator

Dean 1st Year

Numerically

Q.

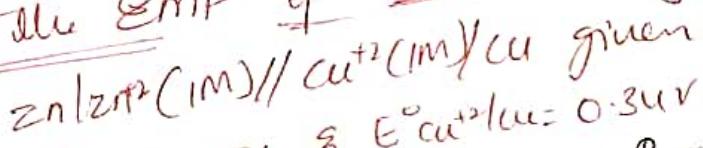
Calculate the electrode potential of Zn/Zn^{+2} electrode
 at 25°C . ($E^\circ_{\text{Zn}/\text{Zn}^{+2}} = 0.76\text{V}$)

$$E = E^\circ - \frac{0.0591}{n} \log [\text{Zn}^{+2}]$$

Half cell Reaction: $\text{Zn} \longrightarrow \text{Zn}^{+2} + 2e$

$$\begin{aligned} E_{\text{Zn}/\text{Zn}^{+2}} &= E^\circ_{\text{Zn}/\text{Zn}^{+2}} - \frac{0.0591}{2} \log (0.01) \\ &= 0.76 - 0.0591 \log (0.01) \\ &= 0.76 - 0.0591 \log 10 \\ &= 0.76 - 0.0591(2) \log 10 \\ &= 0.76 + 0.0591 \\ &= 0.8191\text{V} \end{aligned}$$

Q. Find the EMF of the following cell



$$E^\circ_{\text{Zn}/\text{Zn}^{+2}} = 0.76 \quad \& \quad E^\circ_{\text{Cu}^{+2}/\text{Cu}} = 0.34\text{V}$$

$$E^\circ_{\text{Zn}^{+2}/\text{Zn}} = -0.76\text{V}$$

$$E_{\text{cell}} = E_R^\circ - E_L^\circ$$

$$= E^\circ_{\text{Cu}^{+2}/\text{Cu}} - E^\circ_{\text{Zn}^{+2}/\text{Zn}}$$

$$= 0.34 - (-0.76)$$

$$= 0.34 + 0.76$$

$$= 1.1\text{V}$$

Z

⑨ calculate the electrode potential of copper electrode at 25°C, if $\text{CuSO}_4 = 0.001\text{M}$ & $E^\circ_{\text{Cu}^{+2}/\text{Cu}} = 0.34\text{V}$

$$E = E^\circ + \frac{0.0591}{n} \log (\text{Red})$$

$$E = E^\circ_{\text{Cu}^{+2}/\text{Cu}} + \frac{0.0591}{n} \log [\text{Cu}^{+2}]$$

$$= 0.34 + \frac{0.0591}{2} \log [0.001]$$

$$= 0.34 + \frac{0.0591}{2} \log^{10}^{-3}$$

$$= 0.34 + 0.0591 (-3) \log^{10}$$

$$= 0.34 - 0.08865$$

$$= \underline{\underline{0.25135\text{V}}}$$

⑩ A sample of water gives an analysis 13.6 g/L of CaCO_3 , 7.3 mg/L of $\text{Mg}(\text{ClO}_4)_2$. Calculate the total hardness & permanent hardness.

Salt	weight of salt	Molecular weight	Hardness = $\frac{wt}{Mw} \times 100$
CaSO_4	13.6	136	$\frac{13.6}{136} \times 100 = 10 \text{ mg/l}$
$\text{Mg}(\text{HCO}_3)_2$	7.3	146	$\frac{7.3}{146} \times 100 = 5 \text{ mg/l}$

$$\text{Temporary Hardness} = \text{Mg}(\text{HCO}_3)_2 = 5 \text{ mg/l}$$

$$\text{permanent Hardness} = \text{CaSO}_4 = 10 \text{ mg/l}$$

$$\begin{aligned}\text{Total Hardness} &= \text{Temporary} + \text{permanent} \\ &= 5 \text{ mg/l} + 10 \text{ mg/l} \\ &= 15 \text{ mg/l}\end{aligned}$$

21Q) A sample of hard water contains the following dissolved salts per litre: $\text{CaCl}_2 = 111 \text{ mgs}$, $\text{CaSO}_4 = 1.36 \text{ mgs}$, $\text{Ca}(\text{HCO}_3)_2 = 16.2 \text{ mgs}$, $\text{Mg}(\text{HCO}_3)_2 = 14.6 \text{ mgs}$. Silica = 40 mgs. Turbidity = 10 mgs. Calculate the temporary, permanent & total hardness in ppm?

Hardness causing salt	Weight of salt	Molecular weight of salt	$\text{Hardness} = \frac{\text{wt}}{\text{MW}} \times 100$
CaCl_2	11 mg/L	111	$\frac{11}{111} \times 100 = 100 \text{ mg/L}$
CaSO_4	1.36 mg/L	136	$\frac{1.36}{136} \times 100 = 1 \text{ mg/L}$
$\text{Ca}(\text{HCO}_3)_2$	16.2 mg/L	162	$\frac{16.2}{162} \times 100 = 10 \text{ mg/L}$
$\text{Mg}(\text{HCO}_3)_2$	14.6 mg/L	146	$\frac{14.6}{146} \times 100 = 10 \text{ mg/L}$

Note: Si & Turbidity are not cause hardness to water

$$\begin{aligned}\text{Temporary Hardness} &= \text{Ca}(\text{HCO}_3)_2 + \text{Mg}(\text{HCO}_3)_2 \\ &= 10 + 10 \\ &= 20 \text{ mg/L (or) ppm}\end{aligned}$$

$$\begin{aligned}\text{Permanent Hardness} &= \text{CaCl}_2 + \text{CaSO}_4 \\ &= 100 + 1 \\ &= 101 \text{ mg/L (or) ppm}\end{aligned}$$

$$\begin{aligned}\text{Total Hardness} &= \text{Temporary} + \text{permanent} \\ &= 20 + 101 \\ &= \underline{\underline{121 \text{ mg/L (or) ppm}}}\end{aligned}$$

(25)

50 ml of sample water consumed 20 ml of 0.01M EDTA before boiling & 5 ml after of the same EDTA after boiling. calculate the total, permanent & temporary hardness?

Total Hardness

EDTA vs Hard water

$$M_2 V_2 = M_3 V_3$$

$$M_3 = \frac{M_2 V_2}{V_3}$$

$$\Rightarrow \frac{0.01 \times 20}{50}$$

$$= \underline{\underline{0.004 \text{M}}}$$

$$\begin{aligned} \text{Total Hardness} &= M_3 \times 100 \times 1000 \\ &= 0.004 \times 100 \times 1000 \\ &= 400 \text{ ppm} \end{aligned}$$

$$\begin{aligned} V_2 - \text{volume of EDTA} &= 20 \text{ ml} \\ V_3 - \text{sample H}_2\text{O} &= 50 \text{ ml} \\ M_2 - \text{Molarity of EDTA} &= 0.01 \text{M} \end{aligned}$$

Permanent Hardness

EDTA vs Permanent water

$$M_2 V_2 = M_4 V_4$$

$$M_4 = \frac{M_2 V_2}{V_4}$$

$$M_4 = \frac{0.01 \times 5}{50}$$

$$= \underline{\underline{0.001 \text{M}}}$$

$$\begin{aligned} M_2 - \text{Molarity of EDTA} &= 0.01 \text{M} \\ V_2 - \text{volume of EDTA} &= 5 \text{ ml} \end{aligned}$$

$$\begin{aligned} M_4 - \text{Molarity of permanent water} &= ? \\ V_4 - \text{volume of hardwater after Boiling} &= 5 \text{ ml} \end{aligned}$$

$$\begin{aligned} \text{Permanent Hardness} &= M_4 \times 100 \times 1000 \\ &= 0.001 \times 100 \times 1000 \\ &= 100 \text{ ppm} \end{aligned}$$

$$\begin{aligned} \text{Temporary Hardness} &= \text{Total} - \text{permanent} \\ &= 400 - 100 \\ &= \underline{\underline{300 \text{ ppm}}} \end{aligned}$$

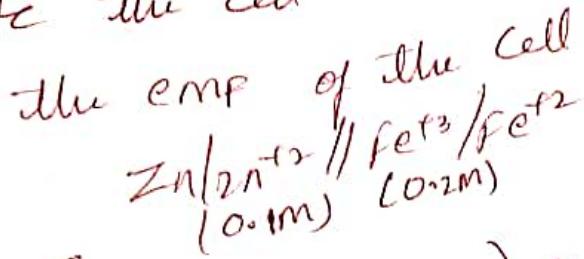
(30) calculate the total hardness of 1000 litre of a water sample containing the following salts
 Impurities 16.2 mg/L - $\text{Ca}(\text{HCO}_3)_2$, 11.1 mg/L
 60 mg/L - MgSO_4 & 19 mg/L - MgCl_2

Salt	weight of salt	Mol.wt of salt	Hardness = $\frac{\text{wt}}{\text{Gmw}} \times 100$
$\text{Ca}(\text{HCO}_3)_2$	16.2	162	$\frac{16.2}{162} \times 100 = 10 \text{ mg/L}$
CaCl_2	11.1	111	$\frac{11.1}{111} \times 100 = 10 \text{ mg/L}$
MgSO_4	60	120	$\frac{60}{120} \times 100 = 50 \text{ mg/L}$
MgCl_2	19	95	$\frac{19}{95} \times 100 = 20 \text{ mg/L}$

$$\begin{aligned}
 \text{Total hardness of water} &= \text{Temporary hardness} + \text{permanent Hardness} \\
 &= \text{Ca}(\text{HCO}_3)_2 + [\text{CaCl}_2 + \text{MgSO}_4 + \text{MgCl}_2] \\
 &= 10 + [10 + 50 + 20] \\
 &= \underline{\underline{90 \text{ mg/L}}}
 \end{aligned}$$

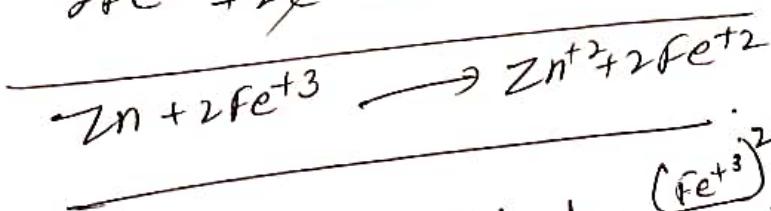
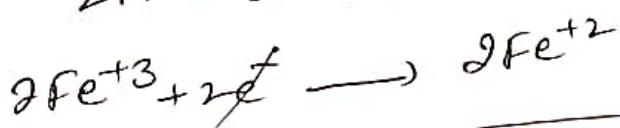
$$\begin{aligned}
 \text{Total hardness for 1000 litres} &= 90 \times 1000 \\
 &= \underline{\underline{90,000 \text{ mg/L}}}
 \end{aligned}$$

(38) Write the cell reaction and calculate
the emf of the cell at 25°C



$$\left\{ E_{\text{Zn}|\text{Zn}^{+2}}^{\circ} = 0.76\text{V} \right. \text{ and } \left. E_{\text{Fe}^{+3}/\text{Fe}^{+2}}^{\circ} = 0.77\text{V} \right]$$

$$E_{\text{Zn}^{+2}/\text{Zn}}^{\circ} = -0.76\text{V}$$



$$E_{\text{cell}} = E_{\text{cell}}^{\circ} + \frac{0.0591}{2} \log \frac{(\text{Fe}^{+3})^2}{(\text{Zn}^{+2})} = E_{\text{cell}}^{\circ}$$

$$= E_{\text{Fe}^{+3}/\text{Fe}^{+2}}^{\circ} - E_{\text{Zn}^{+2}/\text{Zn}}^{\circ} + \frac{0.0591}{2} \log \frac{(0.1)^2}{(0.01)}$$

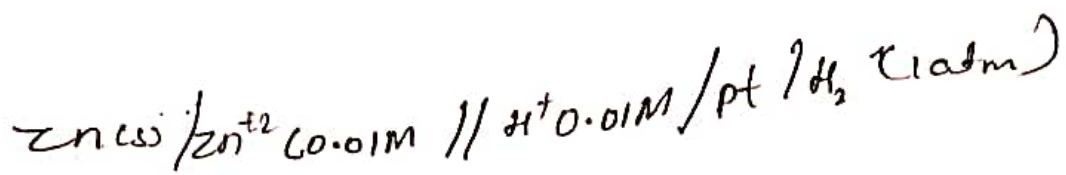
$$= [E_{\text{Fe}^{+3}/\text{Fe}}^{\circ} - E_{\text{Zn}^{+2}/\text{Zn}}^{\circ}] + \frac{0.0591}{2} \log \frac{(0.1)^2}{(0.01)}$$

$$= 0.77 - (-0.76) + \frac{0.0591}{2} \log 1$$

$$= 0.77 + 0.76 + 0$$

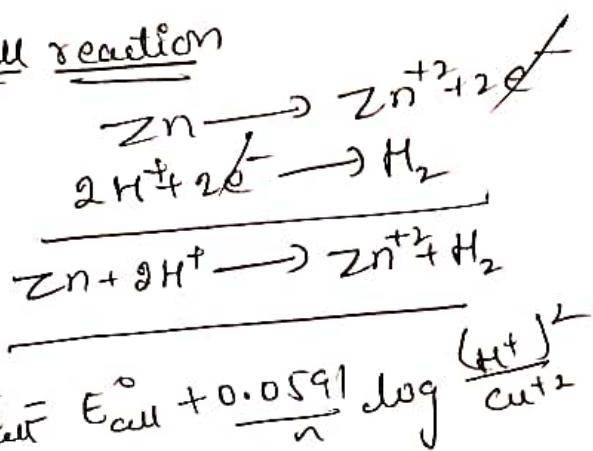
$$= \underline{\underline{1.53\text{V}}}$$

(40)



$$E_{\text{Zn}/\text{Zn}^{+2}}^\circ = 0.76 \text{ V} \quad E_{\text{Zn}^{+2}/\text{Zn}}^\circ = -0.26 \text{ V}$$

$$E_{\text{H}^+/\text{H}_2}^\circ = 0.00 \text{ V}$$

Cell reaction

$$= (E_{\text{H}^+/\text{H}_2}^\circ - E_{\text{Zn}^{+2}/\text{Zn}}^\circ) + \frac{0.0591}{2} \log \frac{(0.01)^2}{(0.01)}$$

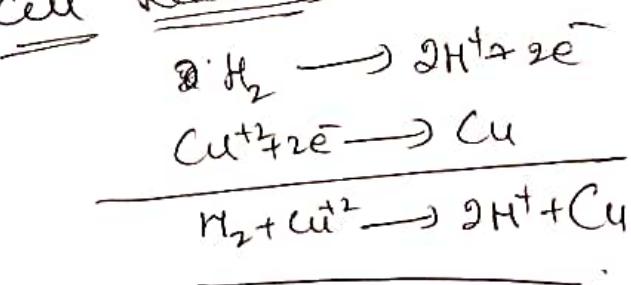
$$= 0.76 - (-0.26) + \frac{0.0591}{2} \log 10^{-2}$$

$$= +0.26 + \frac{0.0591}{2} (-2 \log 10)$$

$$= 0.76 - 0.0591$$

$$= \underline{\underline{0.7009 \text{ V}}}$$

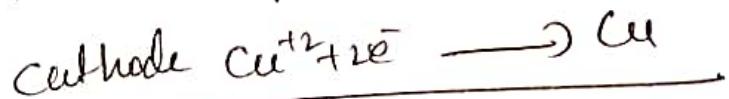
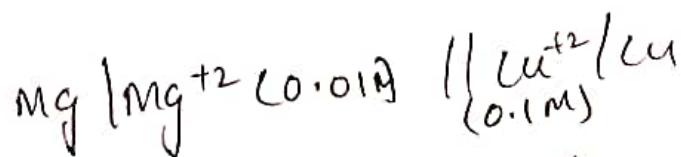
(48)

Cell Reaction

EMF

$$\begin{aligned} E_{\text{cell}} &= E_{\text{cell}}^{\circ} + \frac{0.0591}{n} \log \left[\frac{\text{Cu}^{+2}}{(\text{H}^{+})^2} \right] \\ &= \left[E_{\text{Cu}^{+2}/\text{Cu}}^{\circ} - E_{\text{H}^{+}/\text{H}_2}^{\circ} \right] + \frac{0.0591}{2} \log \frac{0.01}{(0.01)^2} \\ &= [E_{\text{Cu}^{+2}/\text{Cu}}^{\circ} - E_{\text{H}^{+}/\text{H}_2}^{\circ}] + \frac{0.0591}{2} \log \frac{0.1}{(0.01)^2} \\ &= [0.34 - 0] + \frac{0.0591}{2} \log \frac{10000}{10} \\ &= 0.34 + 0.0591 \log 10^3 \\ &\approx 0.34 + 0.0591(3) \log 10 \\ &\approx 0.34 + 0.68865 \\ &\approx 0.428 \text{ V} \end{aligned}$$

(a)



$$E_{\text{Mg}^{+2}/\text{Mg}}^{\circ} = -2.364 \text{ V} \quad E_{\text{Cu}^{+2}/\text{Cu}}^{\circ} = 0.334 \text{ V}$$

$$\begin{aligned} E_{\text{cell}} &= E_{\text{cell}}^{\circ} + \frac{0.0591}{2} \log \frac{\text{Cu}^{+2}}{\text{Mg}^{+2}} \\ &= (E_{\text{Cu}^{+2}/\text{Cu}}^{\circ} - E_{\text{Mg}^{+2}/\text{Mg}}^{\circ}) + \frac{0.0591}{2} \log \frac{0.01}{0.01} \\ &= (0.334 - (-2.364)) + \frac{0.0591}{2} \log \frac{0.01}{0.01} \\ &= (0.334 + 2.364) + \frac{0.0591}{2}(1) \end{aligned}$$

$$\begin{aligned}
 &= 2.698 + \frac{0.0591}{2} \\
 &= 2.698 + 0.02955 \\
 &= \underline{\underline{2.7275 V}}
 \end{aligned}$$

54

<u>Salts</u>	<u>wt of salts</u>	<u>Molecular weight</u>	<u>Hardness = $\frac{wt}{cmw} \times 100$</u>
$\text{Ca}(\text{HCO}_3)_2$	10.5	162	$\frac{10.5}{162} \times 100 = 6.48 \text{ mg/L}$
$\text{Mg}(\text{HCO}_3)_2$	12.5	146	$\frac{12.5}{146} \times 100 = 8.56 \text{ mg/L}$
CaSO_4	7.5	136	$\frac{7.5}{136} \times 100 = 5.51 \text{ mg/L}$
CaCl_2	8.2	111	$\frac{8.2}{111} \times 100 = 7.38 \text{ mg/L}$
MgSO_4	2.6	120	$\frac{2.6}{120} \times 100 = 2.16 \text{ mg/L}$

$$\begin{aligned}
 \text{Temporary Hardness} &= \cancel{\text{Ca}(\text{HCO}_3)_2} + \text{Mg}(\text{HCO}_3)_2 \\
 &= 6.48 + 8.56 \\
 &= 15.04 \text{ mg/L (or) ppm}
 \end{aligned}$$

$$\begin{aligned}
 \text{Permanent Hardness} &= \text{CaSO}_4 + \text{CaCl}_2 + \text{MgSO}_4 \\
 &= 5.51 + 7.38 + 2.16 \\
 &= 15.03 \text{ mg/L (or) ppm}
 \end{aligned}$$

$$\begin{aligned}
 \text{Total Hardness} &= \text{Temp} + \text{permanent} \\
 &= 15.04 + 15.03 \\
 &= \underline{\underline{30.07 \text{ mg/L}}}
 \end{aligned}$$

(65)

Preparation of std CaCO_3 solution

$$\text{wt } M = \frac{\text{wt}}{\text{GMW}} \times \frac{1000}{\text{vcm}^3}$$

$$= \frac{5}{100} \times \frac{1000}{1000}$$

$$= \underline{\underline{0.05M}}$$

Standardisation of EDTA
std CaCO_3 vs. EDTA

$$M_1 V_1 = M_2 V_2$$

$$M_2 = \frac{M_1 V_1}{V_2}$$

M_1 — molarity of 0.05M

std CaCO_3 — 50ml

V_1 — volume of std CaCO_3 — 50ml

V_2 — volume of EDTA = 48ml

$$M_2 = \frac{0.05 \times 50}{48}$$

$$= \underline{\underline{0.052M}}$$

Total hardness

EDTA vs Hard water

$$M_2 V_2 = M_3 V_3$$

$$M_2 = 0.052M$$

$$V_2 = 15 \text{ ml}$$

$$V_3 = 50 \text{ ml}$$

$$M_3 = \frac{M_2 V_2}{V_3}$$

$$= \frac{0.052 \times 15}{50}$$

$$= \underline{\underline{0.0156M}}$$

$$\text{Total hardness} = M_3 \times 100 \times 1000$$

$$= 0.0156 \times 100 \times 1000$$

$$= 1560 \text{ ppm}$$

Permanent Handwritten

EDTA vs Permanent water sample

$$M_2 v_2 = M_4 v_4$$

M₂ — Molarity of EDTA = 0.052M

$$M_4 = \frac{M_2 v}{v_4}$$

V_2 — Volume of EDTA
10 ml

$$= \frac{0.052 \times 10}{50}$$

~~Ans~~ V_4 - volume of Head
water after Boiling
 $= 50 \text{ ml}$

$$= 0.0104 \text{ M}$$

$$\begin{aligned}
 \text{Permanent Hardness} &= \frac{Mg}{100} \times 1000 \\
 &= 0.0104 \times 100 \times 1000 \\
 &= 1040 \text{ ppm}
 \end{aligned}$$

$$\begin{aligned}
 \text{Temporary hardness} &= \text{Total} - \text{permanent} \\
 &= 1560 - 1040 \\
 &= 520 \text{ ppm}
 \end{aligned}$$

(66) Preparation of std CaCO_3

$$\begin{aligned}M &= \frac{\text{wt}}{\text{gmw}} \times \frac{1000}{\text{vml}} \\&= \frac{0.5}{100} \times \frac{1000}{100} \\&= \underline{\underline{0.05M}}\end{aligned}$$

Same - As Question no. (65)

$$\begin{aligned}\text{Total hardness} &= \text{Tempt} + \text{permanent} \\ &= 5 + 30 \\ &= 35 \text{ ppm or mg/L}\end{aligned}$$

$$\text{Hardness in } {}^{\circ}\text{Cl} = \frac{35 \times 0.07}{2.45} = \underline{\underline{2.45 \text{ } {}^{\circ}\text{Cl}}}$$

$$\text{Hardness in } {}^{\circ}\text{Fr} = \frac{35 \times 1}{1.07} = \underline{\underline{3.25 \text{ } {}^{\circ}\text{Fr}}}$$

102b Same as 94

water containing = 156 parts mg $(\text{HCO}_3)_2$

$$\begin{aligned}\text{Hardness} &= \frac{\text{wt of HCS}}{\text{Mol. wt}} \times 100 \\ &= \frac{156}{106} \times 100 \\ &= \underline{\underline{106.8 \text{ ppm}}}\end{aligned}$$

$$\underline{\underline{101}} \quad \text{H.L.} = 12$$

$$\text{HCV} = -1499 \text{ kJ}$$

$$\text{LCV} = ?$$

$$\begin{aligned}\text{LCV} &= \text{HCV} - \frac{q}{100} \times 12 \times 587 \\ &= -1499 - \frac{q}{100} \times 12 \times 587\end{aligned}$$

$$= -2132.96 \text{ kJ}$$

AND

⑧

122

$$C = 75\%$$

$$H = 5.2$$

$$O = 12.1$$

$$N = 3.2\%$$

$$ash = 4.5\%$$

1 kg of Coal contains

$$C = \frac{75}{100} = 0.75 \text{ kg}$$

$$H = \frac{5.2}{100} = 0.052 \text{ kg}$$

$$O = \frac{12.1}{100} = 0.121 \text{ kg}$$

$$N = \frac{3.2}{100} = 0.032 \text{ kg}$$

$$ash = \frac{4.5}{100} = 0.045 \text{ kg}$$

∴ Nitrogen & ash are non combustible substance hence no oxygen required for combustion

Combustion of Carbon



$$12 - 32$$

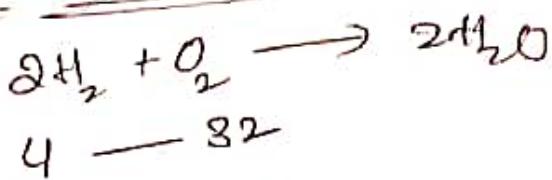
$$0.75 - ?$$

$$0.75 \text{ kg of Carbon required oxygen} = \frac{32}{12} C$$

$$= \frac{32}{12} \times 0.75$$

$$= 2 \text{ kg}$$

Combustion of Hydrogen



$$0.052 \text{ kg} \longrightarrow ?$$

$$0.052 \text{ kg of Hydrogen requires Oxygen} = \frac{32}{4} (\text{H}) \\ = 8(0.052) \\ = \underline{\underline{0.416 \text{ kg}}}$$

$$\text{Total oxygen required} = 2 + 0.416 \\ = 2.416$$

$$\text{Net oxygen required} = \text{Total oxygen} - \text{Available oxygen} \\ = 2.416 - 0.121 \\ = \underline{\underline{2.295 \text{ kg}}}$$

$$\text{Minimum amount of Air required} = \frac{100}{23} (\text{Net O}_2 \text{ reqd}) \\ = \frac{100}{23} \times 2.295 \\ = \underline{\underline{9.97 \text{ kg of Air required}}}$$

$$\textcircled{b} \quad \text{HCV} = \frac{1}{100} (8080C + 34500(H - \frac{O}{8})) + 2200S \\ = \frac{1}{100} (8080(\text{as}) + 34500(S.2 - \frac{12.1}{8})) + 2200(O) \\ = \frac{1}{100} (606000 + 127218.75 + 0) \\ = \frac{1}{100} (733218.75) \\ = \underline{\underline{7332.1875 \text{ k.cal}}}$$

(9)

$$\begin{aligned}
 NCV &= HCV - \frac{9}{100} \text{H.V.S.F} \\
 &= 2332.1875 - \frac{9}{100} (5.2) \times 587 \\
 &= 2332.1875 - 274.716 \\
 &= \underline{\underline{2057.47 \text{ k.cal}}}
 \end{aligned}$$

(124) b



$$12 - 32$$

$$0.5 \text{ kg} \longrightarrow ?$$

Air required for 0.5 kg of coal

$$= \frac{32}{12} \times 0.5$$

$$= \underline{\underline{1.33 \text{ kg}}}$$

$$\text{Minimum air required} = \frac{100}{23} (1.33)$$

$$\therefore \underline{\underline{5.78 \text{ kg}}}$$

128:b

$$C = 80\%$$

$$H = 5\%$$

$$S = 3.2$$

$$N = 2\%$$

$$O = 1$$

$$\text{ash} = 12\%$$

1 kg of coal contains

$$C = \frac{80}{100} = 0.8 \text{ kg}$$

$$H = \frac{5}{100} = 0.05 \text{ kg}$$

$$S = \frac{3.2}{100} = 0.032 \text{ kg}$$

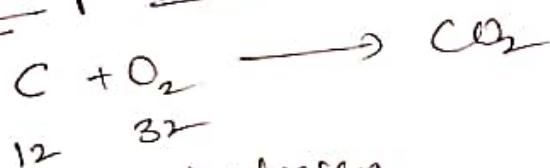
$$N = \frac{2}{100} = 0.02 \text{ kg}$$

$$O = \frac{1}{100} = 0.01 \text{ kg}$$

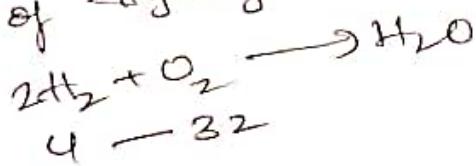
$$\text{ash} = \frac{12}{100} = 0.12 \text{ kg}$$

(Nitrogen & ash are non combustible substance hence not required oxygen)

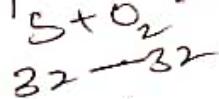
Combustion of Carbon



Combustion of Hydrogen



Combustion of S



$$\text{Minimum air required} = \frac{100}{23} \left(\frac{32}{12} C + 8 \left(H - \frac{O}{8} \right) \right) + S$$

$$= \frac{100}{23} \left(\frac{32}{12} \times 0.8 + 8 \left(0.05 - \frac{0.01}{8} \right) \right) +$$

$$= \frac{100}{23} (2.13 + 0.39 + 0.032)$$

$$= \frac{100}{23} (2.552) = \underline{\underline{11.09}} \text{ kg}$$

(10)

~~minimum~~ minimum amount of air required for complete combustion of 1 kg coal = 11.09 kg

(130)

1 kg of fuel contains

$$C = \frac{85}{100} = 0.85 \text{ kg}$$

$$H = \frac{12}{100} = 0.12 \text{ kg}$$

$$O = \frac{3}{100} = 0.03 \text{ kg}$$

Combustion of carbon



$$12 \longrightarrow 32$$

$$0.85 \longrightarrow ?$$

$$0.85 \text{ kg of carbon requires oxygen} = \frac{32}{12} C$$

$$= \frac{32}{12} \times 0.85$$

$$= \underline{\underline{2.27 \text{ kg}}}$$

Combustion of Hydrogen



$$4 \longrightarrow 32$$

$$0.12 \longrightarrow ?$$

$$0.12 \text{ kg of Hydrogen requires oxygen} = \frac{32}{4} (H)$$

$$= 8(0.12)$$

$$= 0.96 \text{ kg}$$

$$\text{Total oxygen required} = 2.27 + 0.96$$

$$= 3.23$$

$$\text{Net oxygen required} = \text{Total oxygen available}_O_2 - \text{Required}_O_2$$

$$= 3.23 - 0.03$$

$$= 3.2 \text{ kg}$$

Minimum amount of air required = $\frac{100}{23} (3.2)$

$$= \frac{100}{23} (3.2)$$

$$= 13.9 \text{ kg}$$

Minimum amount of air required for complete combustion of 1 kg fuel = 13.9 kg

132 b: same as 130 ↑.

133 1kg of fuel contains

$$C = \frac{81}{100} = 0.81 \text{ kg}$$

$$H = \frac{4}{100} = 0.04 \text{ kg}$$

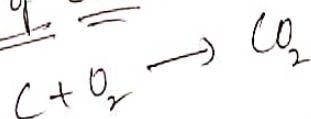
$$O_2 = \frac{2}{100} = 0.02 \text{ kg}$$

$$N = \frac{10}{100} = 0.1 \text{ kg}$$

$$S = \frac{1}{100} = 0.01 \text{ kg}$$

Amount of air required for complete combustion of 1kg fuel = 13.9

Combustion of carbon



$$12 - 32 \quad \text{oxygen} = \frac{32}{12} \times C$$

$$0.81 \text{ kg Carbon requires oxygen} = \frac{32}{12} \times 0.81 \\ = 2.16 \text{ kg}$$

(11)



$$\underline{0.04 \text{ kg hydrogen requires oxygen}} = \frac{32}{4} \times 0.04$$

$$\underline{\text{For Sulphur}} \quad \underline{\text{oxygen required}} = 0.01 = 0.32 \text{ kg}$$

$$\begin{aligned} \text{Total oxygen required} &= 2.16 + 0.82 + 0.01 \\ &= \underline{\underline{2.49 \text{ kg}}} \end{aligned}$$

$$\text{Net oxygen required} = \text{Total} - \text{Available oxygen}$$

$$= 2.49 - 0.02$$

$$= \underline{\underline{2.47 \text{ kg}}}$$

STP volume

32 kg of O₂ occupies 22.4 m³ volume at STP

$$\text{Thus } 2.47 \text{ kg of O}_2 \text{ occupies} = \frac{22.4}{32} \times 2.47$$

$$\boxed{1 = 1.729 \text{ m}^3}$$

As, 21 m³ of O₂ is present in 100 m³ of air at STP
1.729 m³ of O₂ present

$$\therefore \text{Minimum volume of air required for complete combustion of} = \frac{100}{21} \times 1.729$$

$$1 \text{ kg fuel}$$

$$= \underline{\underline{8.23 \text{ m}^3}}$$

134 b

1 kg of coal contains

$$C = \frac{76}{100} = 0.76 \text{ kg}$$

$$H = \frac{5.2}{100} = 0.052 \text{ kg}$$

$$O = \frac{12.8}{100} = 0.128 \text{ kg}$$

$$N = \frac{2.7}{100} = 0.027 \text{ kg}$$

$$S = \frac{1.2}{100} = 0.012 \text{ kg}$$

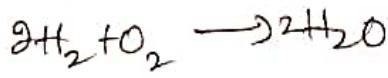
Combustion of carbon



$$12 \longrightarrow 32$$

$$0.76 \text{ carbon requires oxygen} = \frac{32}{12} \times 0.76 \\ = \underline{\underline{2.02 \text{ kg}}}$$

Combustion of hydrogen



$$4 \quad 32$$

0.052 kg of hydrogen requires oxygen

$$= \frac{32}{4} (H)$$

$$= 8(0.052)$$

$$= \underline{\underline{0.416 \text{ kg}}}$$

Combustion of sulphur



$$32 \longrightarrow 32$$

$$0.012 \text{ kg of S required } O_2 = \frac{32}{32} S \\ = \underline{\underline{0.012 \text{ kg}}}$$

(12)

$$\text{Total oxygen requires} = 2.02 + 0.416 + 0.012 \\ = 2.448 \text{ kg}$$

$$\text{Net oxygen requires} = \cancel{\text{Total}} - \frac{\text{Available}}{\text{oxygen}} \text{ oxygen} \\ = 2.448 - 0.128 \\ = 2.32 \text{ kg}$$

32

$$\begin{aligned} &\text{Minimum amount of air required} \\ &\text{for complete combustion} = \frac{100}{23} \times 2.32 \\ &= \underline{\underline{10.08 \text{ kg}}} \end{aligned}$$

O₂ volume required

$$32 \text{ kg of O}_2 \text{ requires } 22.4 \text{ m}^3 \text{ volume} \\ 2.32 \text{ kg of O}_2 \text{ occupies} = \frac{22.4}{32} \times 2.32 \\ = \underline{\underline{1.624 \text{ m}^3}}$$

$$\begin{aligned} &\text{Volume of air required} \\ &\text{for complete combustion} = \frac{100}{21} \times 1.624 \\ &= \underline{\underline{7.73 \text{ m}^3}} \end{aligned}$$

