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SFI GEC PALAKKAD

Course Code: CYT100
Course Name: ENGINEERING CHEMISTRY
(2019-Scheme)

Max. Marks: 100

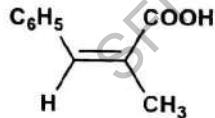
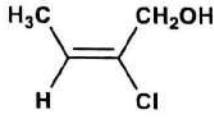
Duration: 3 Hours

PART A

Answer all questions, each carries 3 marks.

Marks

- 1 What will be the standard electrode potential of Ni^{2+} / Ni electrode if the cell potential of the cell $\text{Ni} / \text{Ni}^{2+}(1\text{M}) // \text{Cu}^{2+}(0.1\text{M}) / \text{Cu}$ is 0.59 V at 25 °C? (3)
 $E^0_{\text{Cu}^{2+}/\text{Cu}} = 0.34 \text{ V}$
- 2 Briefly explain the principle of electroless plating. (3)
- 3 Give the mechanism of interaction of electromagnetic radiation with oscillating dipole. (3)
- 4 State Beer-Lambert's law and write the differential form. (3)
- 5 Write any three differences of TGA and DTA. (3)
- 6 Explain sol-gel method for the synthesis of nano particles (3)
- 7 Determine the configuration of the following alkenes as **E** or **Z**: (3)



- 8 Mention any three advantages of OLEDs over LED and LCD. (3)
- 9 Explain disinfection by chlorination. (3)
- 10 Compare BOD and COD. (3)

PART B

Answer one full question from each module, each question carries 14 marks

Module-I

- 11 a) Explain the mechanism of electrochemical corrosion in different environmental conditions. (10)
- b) How is the cell constant of a conductivity cell measured? (4)

- 12 a) Describe the construction and working of Li-ion battery. What are the major advantages of it? (4)
- b) Calculate the EMF of the cell at 25°C:
 $\text{Al} / \text{Al}^{3+}(0.1\text{M}) // \text{Sn}^{4+}(0.1\text{M}) / \text{Sn}^{2+}(0.01\text{M})$
 $E^0_{\text{Al}^{3+}/\text{Al}} = -1.66 \text{ V}, E^0_{\text{Sn}^{4+}/\text{Sn}^{2+}} = 0.15 \text{ V}$

Module-II

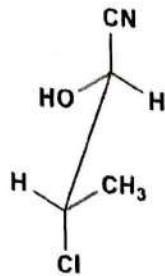
- 13 a) Define chemical shift in NMR and explain the factors affecting chemical shift with examples. (8)
- b) Calculate the force constant of H-F molecule that is showing IR absorption signal at 4000 cm⁻¹. By what factor do you expect this frequency to shift if Deuterium is substituted for Hydrogen in this molecule? Given that atomic masses of H and F are 1u and 19 u, respectively. (6)
- 14 a) How many vibrational modes are possible for the molecules CO, NO, CO₂ and H₂O? Draw the vibrational modes of CO₂ and H₂O and explain their IR active modes. (8)
- b) Each compound gives only one signal in its ¹H-NMR spectrum. Propose a structural formula for each. a) C₈H₁₈ and b) C₈H₁₈O (6)

Module-III

- 15 a) Describe the instrumentation, principle and working of SEM with the help of a labelled diagram. Give any two applications. (10)
- b) Explain the visualization techniques used in thin layer chromatography. (4)
- 16 a) Describe the principle, instrumentation, procedure and applications of HPLC. (10)
- b) How TGA is used to analyze thermal stability of polymers? (4)

Module-IV

- 17 a) Discuss the conformations in butane by depicting the Newman formula about C₂-C₃ bond of all the conformers. Also draw the energy level diagram with dihedral angle. (10)
- b) How is ABS synthesized? Mention some applications. (4)
- 18 a) Explain the rules for assigning **R-S** configuration and determine the **R-S** configuration of all the asymmetric carbon atoms in the molecule after writing its Fischer projection formula. (8)



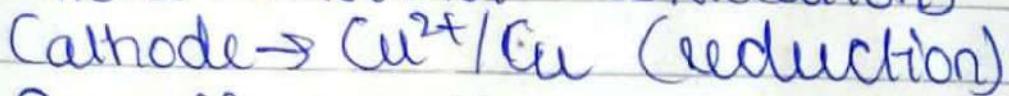
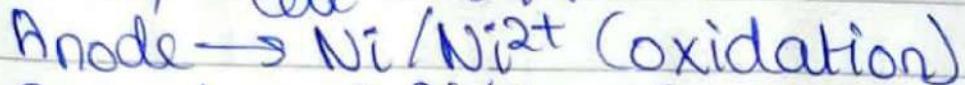
- ✓ b) What is meant by doping of polymers? Describe the different types of doping. (6)

Module-V

- 19 a) Describe the steps involved in municipal water treatment. (10)
- b) The following data are obtained for a hard water sample from an EDTA experiment (4)
- i) 20 mL standard hard water (5 g/L CaCO_3) = 25 mL EDTA solution
 - ii) 100 mL of hard water sample = 24 mL EDTA solution
 - iii) 100 mL of boiled hard water sample = 18 mL EDTA solution
- Calculate the temporary and permanent hardness.
- 20 a) With the help of a flow diagram explain the steps involved in sewage treatment. (10)
- b) Calculate the temporary and permanent hardness of water sample containing the following dissolved salts. (4)
- $\text{Ca}(\text{HCO}_3)_2 = 28 \text{ mg/L}$; $\text{CaSO}_4 = 18 \text{ mg/L}$; $\text{Mg}(\text{HCO}_3)_2 = 32 \text{ mg/L}$;
 $\text{MgCl}_2 = 30 \text{ mg/L}$; $\text{NaCl} = 58 \text{ mg/L}$.

$$1) E_{\text{cell}} = E_{\text{cell}}^{\circ} - \frac{0.0591}{n} \log \frac{[\text{Anode}]}{[\text{cathode}]}$$

$$n=2, E_{\text{cell}} = 0.59 \text{ V}$$



Overall reaction



$$0.59 = E_{\text{cell}}^{\circ} - \frac{0.0591}{2} \log \frac{1}{10^{-1}}$$

$$0.59 = E_{\text{cell}}^{\circ} - \frac{0.0591}{2} \log 10$$

$$E_{\text{cell}}^{\circ} = 0.59 + \frac{0.0591}{2} = 0.619$$

$$\Rightarrow E_{\text{cell}}^{\circ} = E_{\text{C}}^{\circ} - E_{\text{A}}^{\circ}, E_{\text{Cu}^{2+}/\text{Cu}}^{\circ} = 0.34 \text{ V}$$

$$\Rightarrow E_{\text{H}}^{\circ} = E_{\text{C}}^{\circ} - E_{\text{cell}}^{\circ} = 0.34 - 0.619$$

$$E_{\text{H}}^{\circ} = -0.279 \text{ V}$$

$$E_{\text{Ni}^{2+}/\text{Ni}}^{\circ} = -0.279 \text{ V} //$$

③ Briefly explain the principle of electroless plating.

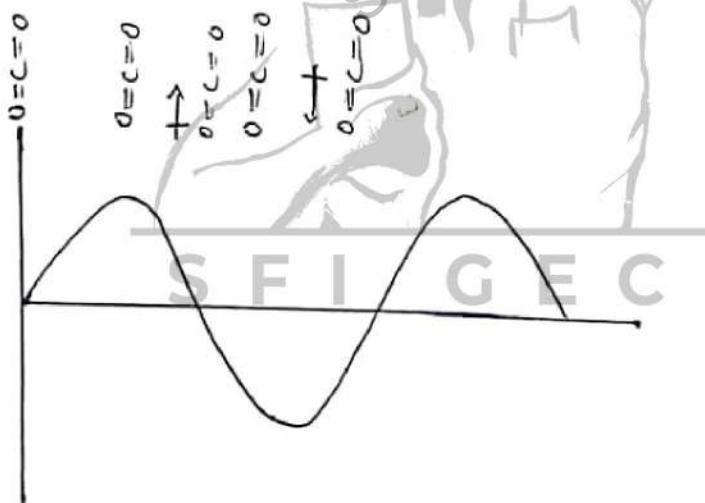
Ans) Electroless plating is defined as a controlled autocatalytic deposition of continuous layer of a noble metal from its salt solution on a catalytic surface of the base metal by using a suitable reducing agent without using electrical energy.

Principle: Here the substrate is placed in a plating bath containing metallic ions, reducing agents, complexing agent, stabilizers and other components, and it develops a potential. This is a non-galvanic plating method which involves several simultaneous reactions which occur without the use of external electrical power. The reaction is accomplished when hydrogen is released by a reducing agent, normally sodium hypophosphite, and oxidised, thus producing a negative charge on the surface of the metal. Key requirement of this type of bath is ~~not~~ to arrange the chemistry such that the kinetics of homogeneous electron transfer from reducing agent to the metal ion is slow. This is essential because otherwise the metal ion would simply be reduced in the bulk solution. A catalyst that accelerates the rate of metal ion reduction is thus applied to the surface to be coated. In this way metal ions are reduced only at the surface and the surface becomes coated with desired metal.

③ Give the mechanism of interaction of electromagnetic radiation with oscillating dipole

Ans). During the vibration of a molecule if there occurs a change of dipole moment, it will lead to the generation of an oscillating electric field and act as a source of electromagnetic radiation. Similarly when a photon of frequency comes in resonance with the frequency of vibration of a molecule, the absorption of molecule takes place and the molecule starts oscillating with the frequency of the radiation.

Consider the asymmetric vibration of CO_2 , a fluctuating electric field produced is as shown



4. Beer-Lambert's law:

When a beam of monochromatic radiation is allowed to pass through a transparent medium, a rate of decrease of intensity ($-dI$) with the thickness of the absorbing medium (dc) is proportional to the intensity of incident radiation as well as to the concentration of the solution (c).

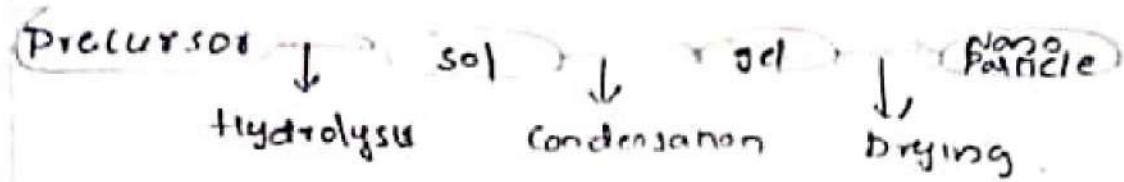
$$-\frac{dI}{dc} \propto I^c \cdot C$$

5)

Thermogravimetric analysis (TGA)	Differential thermal analysis (DTA)
Type of Molecule is lost during a decomposition can be determined.	No such information.
No information Regarding Melting point phase transition temperature of a solid.	Melting point phase transition temperature can be measured.
No information Regarding glass transition (T_g) temperature of a polymer.	Glass transition (T_g) temperature of a polymer can be determined.
Rate of evaporation Of a liquid can be determined.	No such information

S F I G E C

⑥ Sol-gel method for preparation of nanomaterials

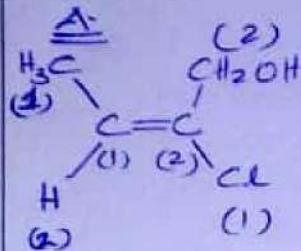


'sol' means \rightarrow colloidal system of nano particle dispersed in liquid

'gel' means \rightarrow colloidal system of liquid droplet in a network of solid nano particles.



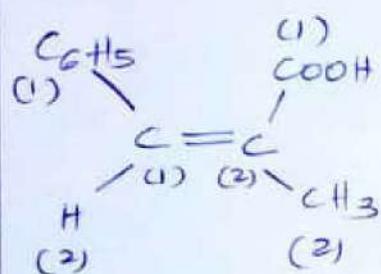
7.



In case of first carbon, it has two substituents which are H and CH₃. Here, Carbon has higher atomic number and hence CH₃ has 1st priority and H gets priority 2.

In carbon number 2, the two substituents are linked to a Cl and a Carbon. Since Cl has higher atomic number than 'C', Cl gets priority (1) and C gets 2.

Since both substituents numbered 1 are on the opposite side the configuration is E.

B

Here in 1st carbon, the two substituents are C₆H₅ and H. Since 'C' has higher atomic number than H, C₆H₅ is numbered 1 and H numbered 2.

As for carbon number two, both substituents have 'C' as the linked atom. Hence we will look at the atom to which this 'C' is attached to. In case of COOH, C is attached to 'O' and in case of CH₃ to H. Since 'O' has higher atomic number compared to H, Paris COOH is numbered 1 and CH₃ numbered 2.

Since both 1's are on the same side, this is called a Z configuration.

(8) Mention any three advantages of OLED over LED and LCD.

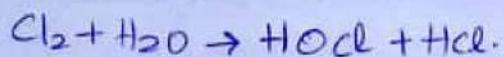
Ans) Advantages of OLED are as follows.

- * The manufacture of OLED is highly economical and is more efficient than LCD, LED and flat panel screens.
- * No backlight is produced by this device and the power consumption is very less.
- * Response time of OLED is less than 0.01ms. LCD's are capable of having response time between 1 and 16ms.
- * OLED can theoretically have a refresh rate of 100,000Hz which is almost 9000Hz greater than an LCD display. LED can theoretically have a refresh rate of 10,000Hz.
- * There is much difference in watching a LCD or LED TV to an OLED display. As the contrast ratio of OLED is very high. It can be watched from an angle nearly 90° without any difficulty.

9. Disinfection is the process of killing pathogenic bacteria and other micro-organisms in water.

Chlorination is one of the most common methods of ~~chlorination~~ disinfection.

Chlorine, when added to water, either in liquid or gaseous form produces HOCl.

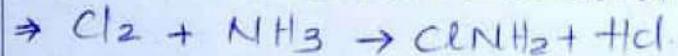


HOCl kills microorganisms by destroying their enzymes. Chlorinator is usually the apparatus used for chlorination, and it contains a large number of baffle plates. Water along with concentrated chlorine solution are introduced from the top. As they move down, mixing occurs and disinfection as well.

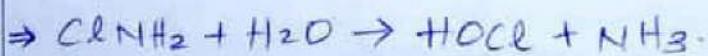
Types of chlorination are break point chlorination, chlorination using chloramine and by adding bleaching powder.

* Break point chlorination refers to the addition of chlorine to water in amounts sufficient to kill all microorganisms and destroy it completely. It also removes impurities like organic matter, reducing agents, colouring materials, free ammonia etc.

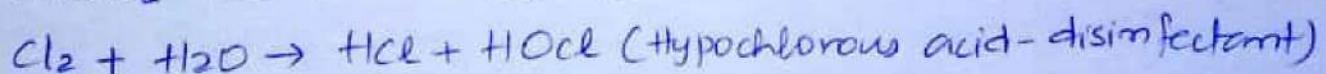
* Chloramine method involves adding chloramine ($ClNH_2$) to water. It is more long lasting compared to pure chlorine. It is produced by mixing 2 parts chlorine and 1 parts ammonia by volume. It also disinfects by releasing HOCl. This method leaves no odour and imparts good taste.



2 parts 1 part chloramine



* Adding bleaching powder ($CaOCl_2$) can be employed in small scale purification. 1 kg bleaching powder is mixed with 1000 kilolitres of water to get desired disinfection.



10)

BOD	COD
BOD is the amount of oxygen consumed by bacteria while decomposing organic matter under aerobic conditions.	COD is the amount of oxygen required for the oxidation of total organic matter in water.
Biological oxidation process.	Chemical oxidation process.
Five days are taken for the determination.	COD measurement can be taken from few days.
Value is lower than COD value.	Always greater than the BOD value.
Capable of oxidizing natural organic detritus and the organic waste in the water.	Capable of degrading industrial sewage, but does not measure the oxygen consumption of acetate.

II a) Corrosion is the process of disintegration or deterioration of a metal by chemical or electrochemical reaction with the environment.

Wet or electrochemical corrosion takes place via four mechanisms.

These four mechanisms could be further classified into two:

(1) Hydrogen evolution corrosion

(2) Oxygen absorption corrosion.

HYDROGEN EVOLUTION CORROSION :-

Hydrogen evolution corrosion has a different mechanism of which one occurs in acid medium, whilst the other in alkaline medium.

a) ACID MEDIUM:

This occurs when metals are in contact with acidic medium in the absence of sufficient oxygen.

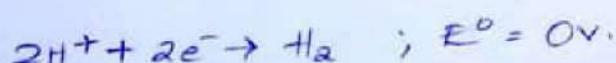
At anode

Eq: Fe in acid medium.

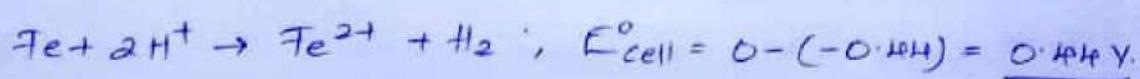
At anode Fe gets oxidised into Fe^{2+} :



At cathode hydrogen ions get reduced to hydrogen gas.



Net reaction:

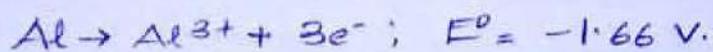


In this type of corrosion, hydrogen gets displaced as H_2 gas and hence the name "hydrogen evolution" in acidic medium.

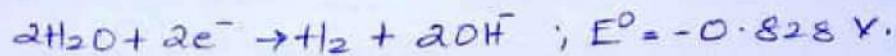
b) In ALKALINE MEDIUM:-

Unlike acid medium corrosion doesn't take place in case of Fe in alkaline medium. However aluminium undergoes hydrogen evolution corrosion under alkaline condition in the absence of sufficient oxygen.

At anode:



At cathode:



$$\text{Corrosion cell potential} = E_c - E_a = -0.828 - (-1.66) = \underline{\underline{0.832 \text{ V}}}$$

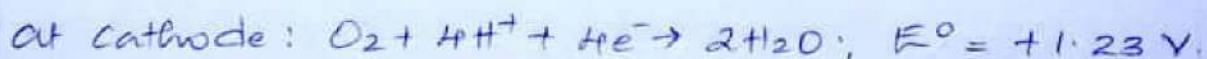
OXYGEN ABSORPTION CORROSION:

Oxygen absorption corrosion also has different mechanism in acidic and alkaline medium.

a) ACID MEDIUM.

This occurs in acidic or even neutral medium when metals are in contact with water having dissolved oxygen.

Eg: Rusting of Iron.



$$\text{Corrosion cell potential} = 1.23 - (-0.444) = 1.67 \text{ V.}$$

In acidic or neutral conditions, Fe^{2+} gets further oxidised to Fe^{3+} since oxygen electrode potential is greater than $E^\circ_{\text{Fe}^{3+}/\text{Fe}^{2+}}$.

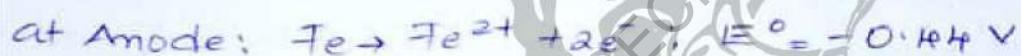
The Fe^{3+} formed here will form an insoluble precipitate of

Fe(OH)_3 called yellow rust. If the amount of moisture is less, black rust- $\text{FeO} \cdot \text{Fe}_2\text{O}_3$ is formed.

Rust formation eventually leads to intense localised corrosion called pitting corrosion. This is due to the formation of separate anodic and cathodic area. The precipitate adhered area which is not in contact with oxygen is anodic area. In this area, iron oxidises and forms pits. Oxygen exposed area becomes cathodic.

b) ALKALINE MEDIUM

This occurs when metals are in contact with water having dissolved oxygen in alkaline environment.



$$\text{Here, Corrosion cell Potential} = 0.40 - -0.444 = \underline{\underline{0.84 \text{ V}}}$$

In alkaline environments Fe^{2+} does not get oxidised to Fe^{3+} . Since oxygen electrode potential is lower than $E^\circ_{\text{Fe}^{3+}/\text{Fe}^{2+}}$ in alkaline medium

These are the four mechanisms of electrochemical corrosion.

- b). Conductivity cells are usually used to measure the conductivity of electrolytic solution. Cell constant is a characteristic feature of a conductivity cell and is defined as the ratio of distance between its electrodes (l) and area of electrodes (a).

But precise measuring l and a is rather difficult and hence in practice, we measure it by filling the conductivity

cell using a solution of known conductivity like 0.1 M KCl solution. We know that

Now, Conductivity of 0.1 M KCl solution (K) =

$$\text{conductance} (C) \times \text{cell constant}$$

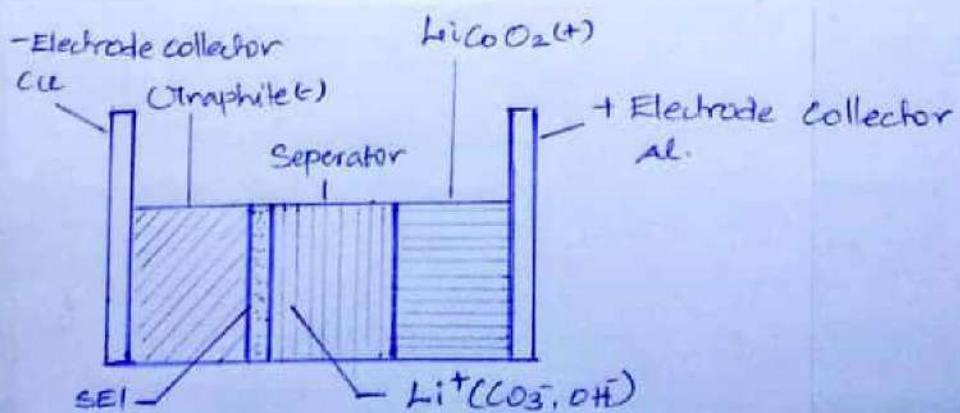
Cell constant can be determined by measuring conductance of 0.1 M KCl solution, since we know that the value of K is $0.01288 \text{ S cm}^{-1}$ for KCl at 298 K.

12.
(a)

Lithium ion cell is a rechargeable battery in which, Li^+ ion moves between cathode and anode during charging and discharging.

Construction of lithium ion cell:

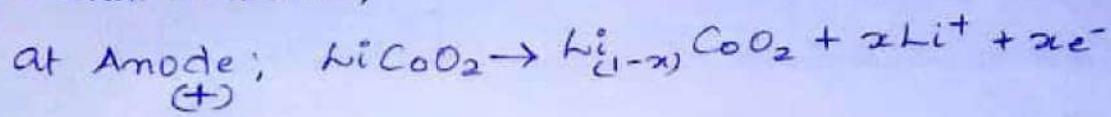
Usually the positive electrode is made using a crystalline mixed oxide LiCoO_2 or $\text{Li}_2\text{O} \cdot \text{Co}_2\text{O}_3$. This crystal contains both Li^+ ion and Co^{3+} ion occupying the voids of the oxide array. Negative terminal is usually made up of graphite. Electrolyte used is usually a solution of Li^+ salt (LiPF_6 , LiBF_4 or LiClO_4) in an organic solvent such as ether or a solid phase polymer electrolyte which can transport Li^+ ion. Anode and cathode compartments are usually separated using a Solid Electrolyte Separator (SEI).



Working of Li-ion battery:

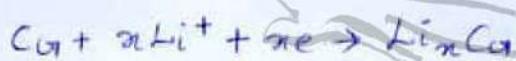
During charging, the cell acts as an electrolytic cell and converts electrical energy to chemical energy.

In such situations;



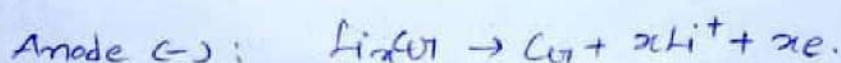
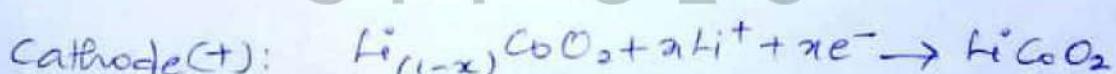
(+) Here some Li^+ ions escape the crystal lattice and Co^{3+} oxidized to Co^{4+} to maintain electrical neutrality.

at Cathode (-) :



The Li^+ ions migrates through electrolyte from anode and get reduced to lithium atom at graphite cathode.

During discharging, the cell acts as an electrochemical cell and the chemical energy is converted to electrical energy. During discharging, graphite acts as anode, while LiCoO_2 acts as cathode.



And now Li^+ ions migrate back to their original lattice in LiCoO_2 .

Advantages of Li-ion battery :-

- (1) High energy to weight ratio
- (2) Long lasting
- (3) Available in standard industry sizes.

b) Given cell representation gives the following data:

$$[Al^{3+}] = 0.1 M, [Sn^{4+}] = 0.1 M, [Sn^{2+}] = 0.01 M.$$

Also given: $E^\circ_{Al^{3+}/Al} = -1.66 V$, $E^\circ_{Sn^{4+}/Sn^{2+}} = 0.15 V$

If such a cell is constructed, the standard cell potential

$$E^\circ = E_c - E_A$$

From given data of E° values, we can see that

$$E^\circ_{Sn^{4+}/Sn^{2+}} > E^\circ_{Al^{3+}/Al}$$

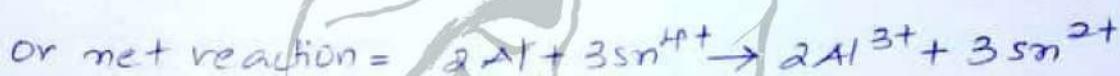
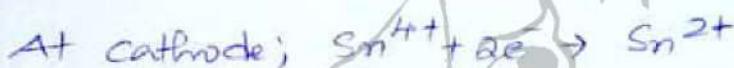
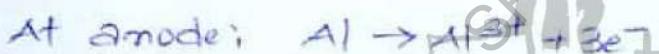
Hence Sn will act as cathode and aluminium as anode.

Then, $E^\circ = 0.15 - (-1.66) = \underline{1.81} V$

At conditions given in the question;

$$E_{cell} = E^\circ_{cell} - \frac{0.0591}{n} \log \frac{[products]}{[reactants]}$$

For that we will have to write cell reaction.



S F with no. of e^- transferred, $n = \underline{6e^-}$

$$\text{Hence } E_{cell} = E^\circ_{cell} - \frac{0.0591}{6} \log \frac{[Al^{3+}]^2 + [Sn^{2+}]^3}{[Sn^{4+}]^3}$$

$$= 1.81 - \frac{0.0591}{6} \log \frac{[0.1]^2 + [0.01]^3}{[0.1]^3}$$

$$= 1.81 - \frac{0.0591}{6} \log (10.001)$$

$$= 1.81 - \frac{0.0591}{6} \quad \xrightarrow{\text{log 10.001 } \approx 1}$$

$$= 1.81 - 0.00985 = \underline{1.80015} V$$

3a) Chemical shift : It is defined as the shift in radio-frequency to the operating frequency of the instrument due to the shielding or deshielding of hydrogen nucleus in different structural environment.

$$\text{Chemical shift } (\delta) = \frac{\nu_{\text{sample}} - \nu_{\text{reference}}}{\text{Operating frequency in MHz}}$$

Instead of measuring chemical shifts in absolute terms, we measure them with respect to a standard-tetramethylsilane ($(\text{CH}_3)_4\text{Si}$), abbreviated as TMS.

Factors affecting chemical shift

Electronegativity: In shielding the induced magnetic field opposes the applied field. Therefore as the electron density around proton decreases, shielding effect decreases and δ value increases. In compounds of the type CH_3X , for example the shielding of the methyl protons decreases as X becomes more electronegative. Thus chemical shift depends on the degree to which X draws electrons from the methyl group.

CH_3F	$(\text{CH}_3)_2\text{O}-\text{CH}_3$	$(\text{CH}_3)_3\text{N}$	CH_3-CH_3
S of CH_3 protons	4.3	3.2	2.2

Decreasing electronegativity of attached atoms
increased shielding of methyl protons

- (ii) Cumulative effects of electronegative substituents: The deshielding effects of electronegative substituents are cumulative, as the chemical shifts of various chlorinated derivatives of methane indicate.

CHCl_3 chloroform	CH_2Cl_2 dichloromethane	CH_3Cl chloromethane
8	7.3	3.1

3. (iii) Distance from the electronegative atoms: When an electronegative atom is substituted in the hydrogen chain, the electron density around the proton decreases as the proton gets closer towards the electronegative atom. As the electron density around proton domain shielding effect decreases, i.e. ~~shields~~ increases. Eg: $\text{CH}_3-\text{CH}_2-\text{CH}_2\text{Cl}$

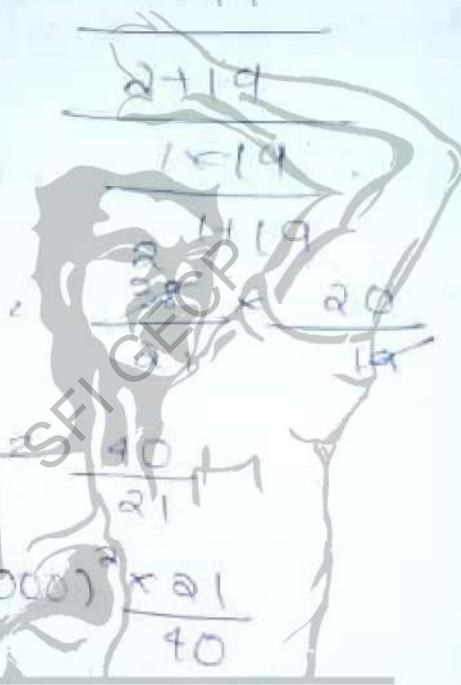


$$\bar{v}_2^2 \propto 1/\mu$$

[when deuterium is substituted for hydrogen force constant remains same].

$$\therefore \frac{\bar{v}_1^2}{\bar{v}_2^2} = \frac{M_2}{M_1}$$

$$\frac{4000 \times 4000}{\bar{v}_2^2} = 2 \times 19$$



$$\therefore \bar{v}_2^2 = \frac{(4000) \times 21}{40}$$

$$\therefore \bar{v}_2 = S F 4000 \frac{G_a E}{V} C_m^{-1}$$

$$= 4000 \times 0.724 \text{ cm}^{-1}$$

It changes by a factor of $\sqrt{\frac{21}{40}}$ i.e. 0.724.

i) Deshielding : In deshielding the induced magnetic field reinforces the applied magnetic field. Therefore deshielding effect increases the value of δ . For aromatic protons δ -value lies between 6.5 to 8.5.

Eg: H-R δ value lies in between 0.9 to 1.8

H-C₆H₅-R δ value lies in between 2.7 - 4.1

H-CO-R δ value lies in between 9 - 10.

$$k = \frac{4\pi^2 \epsilon (\sigma)^2}{\mu} \cdot \frac{4\pi^2 (C\mu)^2}{H}$$

Reduced mass μ is given by $\mu = \frac{m_1 m_2}{m_1 + m_2}$

$$\frac{1.1 \times 19}{119} \times 1.66 \times 10^{-27}$$

$$1.577 \times 10^{-27} \text{ kg}$$

$$k = 4 \times \frac{3 \times 10^4 F^2 \times 1}{(3 \times 10^8 E)^2 \times C (000)^2} \times 1.577 \times 10^{-27}$$

$$= 4 \times (314)^2 \times 9 \times 10^{16} \times 16 \times 10^6 \times 1.577 \times 10^{-27} \times 10^9$$

$$= 859.8955.98 \times 10^{-1}$$

$$= 895.5 \text{ Nm}^{-1}$$

14

a.)

CO : Carbon monoxide is a linear molecular and hence the total possible vibrational modes are given by $3n-5$, where $n = \text{no of atom}$.

$$\text{Here possible modes} = (3 \times 2) - 5 = 6 - 5 = \underline{\underline{1}}$$

NO : NO is also linear molecule with $n=2$.

$$\text{Hence, vibrational modes} = (3 \times 2) - 5 = \underline{\underline{1}}$$

CO_2 : CO_2 is a linear molecule with no of atoms = 3

$$\text{possible vibrational modes} = (3 \times 3) - 5 = \underline{\underline{4}}$$

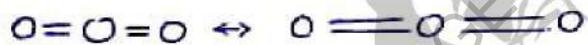
H_2O : H_2O is non linear molecule with $n=3$.

$$\begin{aligned} \text{Here, possible vibrational modes} &= 3n-6 \\ &= (3 \times 3) - 6 = \underline{\underline{3}} \end{aligned}$$

Vibrational modes of CO_2 :

CO_2 has 4 modes of vibrations.

(1) Symmetrical Stretching:



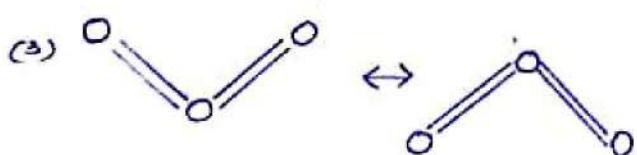
Here the dipole moments gets cancelled out and the molecule is non-polar. Hence this mode is IR inactive.

(2) Asymmetrical stretching:



This mode of vibration produces fluctuating moments and they are IR active in this mode. And hence it produces a peak in spectra.

(3) & (4) Symmetrical bending (scissoring).



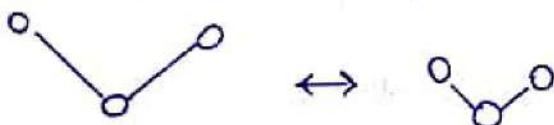
These two modes of vibrations are degenerate and differs only in direction. Since they are IR active, both gives a single peak together due to their degeneracy.

And hence, in the IR spectra of CO_2 , we can see only two peaks. One due to asymmetrical stretching and the other due to asymmetric bending.

Vibrational modes of H_2O

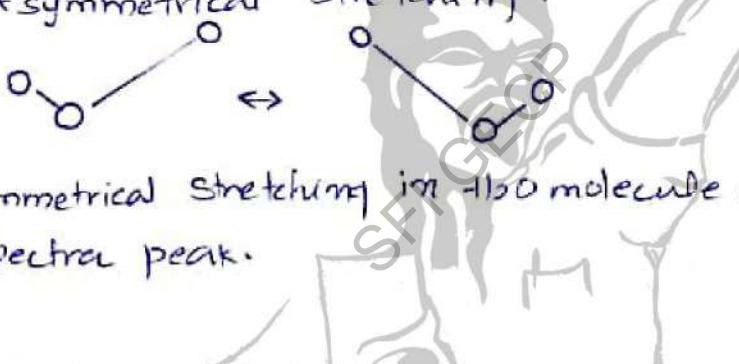
H_2O has 3 modes of vibration.

(1) Symmetrical Stretching :-



Since the shape of H_2O molecule is a bent and not linear like CO_2 , Symmetric stretching does result in change of dipole moment and this mode is indeed IR active.

(2) Asymmetrical Stretching :-



Asymmetrical stretching in H_2O molecule also results in an IR spectral peak.

(3) Symmetrical bending in H_2O :-

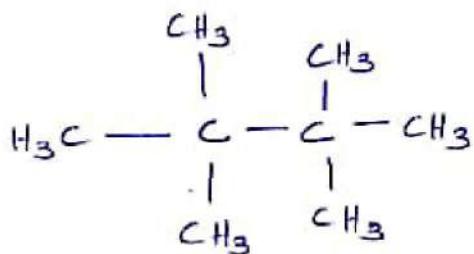


Symmetrical bending also results in a peak in IR spectra of H_2O .

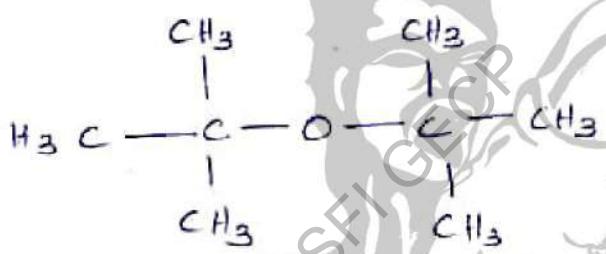
Since the two ~~O-H~~ O-H bonds in H_2O are identical, the two stretching vibrations cannot produce separate peaks and forms a large peak that is somewhat merged and we end up with a spectra that looks more like it has 2 peaks with one of them being massive.

b) Each compound gives only one type of signal implies that all the hydrogen atoms in the molecule has the same environment or simply put, they are all equivalent. Hence, any possible structure where all hydrogen atoms are equivalent would suffice the above criterion.

hence; structure of a) C_8H_{18}



Structure of b) $C_8H_{18}O$



S F I G E C

articles.

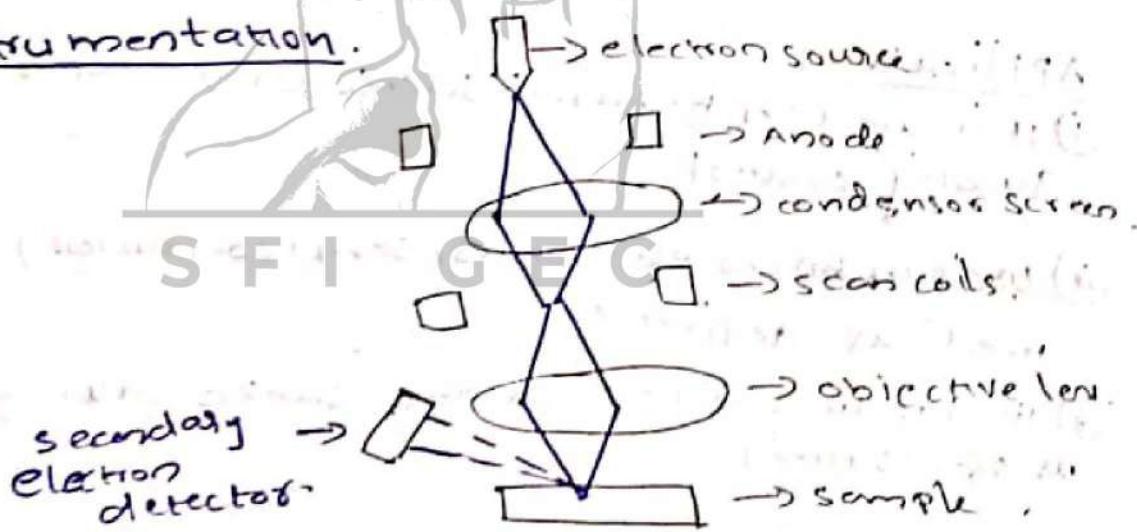
(15)

SEM (Scanning Electron microscope)

principle

It is a type of electron microscope that produces images of sample by scanning the surface with a focused beam of electrons. Electrons will interact with atoms present in the sample & produce various signals that contains important information about the sample. When electrons interact with sample they produce secondary electrons, scattered electrons & X-rays. These signals are collected by detector to form image which are then displayed in computer screen.

Instrumentation.



SEM uses a focused beam of high energy - electron to generate a variety of signals at the surface of solid specimens. The generated electron pass through the direction as indicated by the figure and there will be atleast one detector to detect the secondary electron generated.

Working

In SEM, the electron beam scan the sample in raster pattern, first electrons are generated at the top of the column by the electron source. There are emitted when their thermal energy overcome the work function of the source material. They are then accelerated & attracted by the positively charged anode. The entire column needs to be under vacuum like all component of an electron microscope. The electron source is sealed inside a special chamber to preserve vacuum & protect it against contamination, vibrations & noise. Beside protecting the electron source from being contaminated, vacuum also allows the user to acquire a high-resolution image. In the absence of vacuum, other atoms & molecules can be present in the column. Their interaction with electrons cause the electron beam to deflect & reduces the image quality. High vacuum also increases the collection efficiency of electrons by the detectors that are in the column.

Applications

- ① It is used in material science for research & quality control
- ② Used in microelectronics, semiconductors, medical device etc.
- ③ It produce images of the sample viewing size as of (15nm)

- (b) ① using uv-lamp → The silica gel on the TLC plate is impregnated with a fluorescent material that glows under ultraviolet light. A spot will interfere with the fluorescence & appear as a dark spot on glowing background.
- ② using iodine vapour → A second method of visualization is accomplished by placing the plate into iodine vapours for a few minutes. Most organic compounds will form a dark-coloured complex with iodine.
- ③ using chemical reagents → This converts the compound into a coloured compound, enabling the spot to be seen with the naked eye.



16 @ HPLC → (Principle)

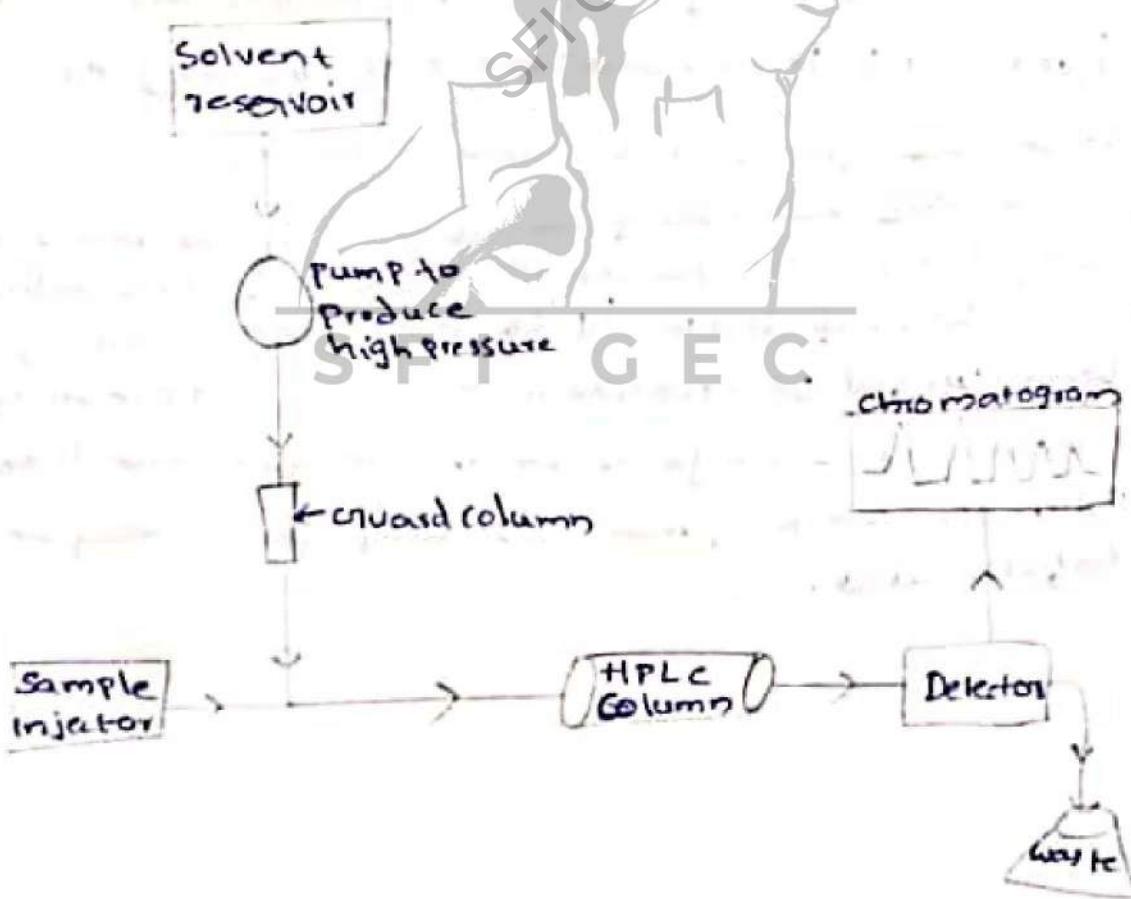
→ High Performance liquid chromatography also can be called as high pressure liquid chromatography. It is mainly used in the case of thermally unstable components,

here the components are separated by the passage of sample using a pressurised flow of liquid mobile phase, through a columnning solid phase. The sample moves according to their attraction towards the solid phase.

Here,

- Solid phase is particles like silicon polymers etc..
- mobile phase is solvent mixture of (Acetonitrile & H₂O)

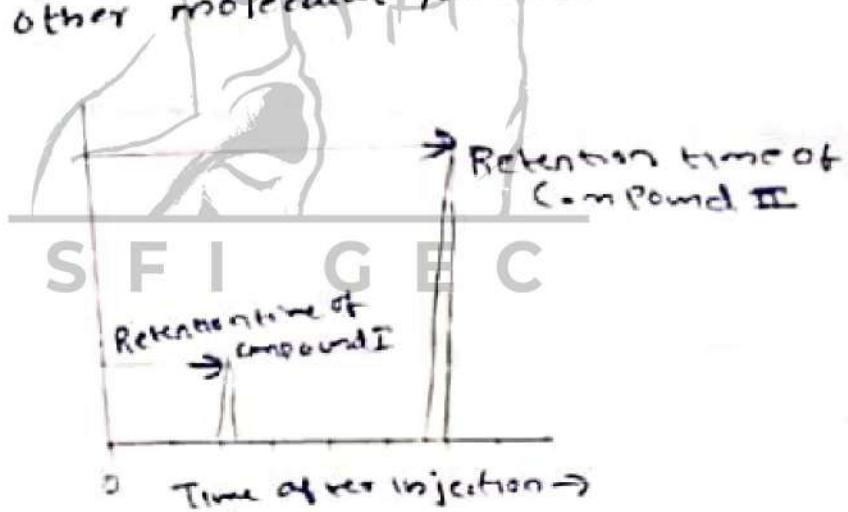
Instrumentation



Procedure.

Here the solvent substance is made run through a pump where it gets high pressurized & the sample to be tested is mixed with this high pressurized solvent & is made to enter the HPLC column, where different components are separated according to the principle of attraction between the two phases accordingly. The detector reads the data and with the help of computer data station chromatogram is made, which helps in identification of compound according to the position & shape of the chromatogram.

The identification of each compound in the sample, most common parameter for compound identification is its retention time (the time it takes for that specific compound to elute from the column after injection), depending upon the detector used compound identification is also based on the chemical structure, molecular weight or some other molecular parameter.

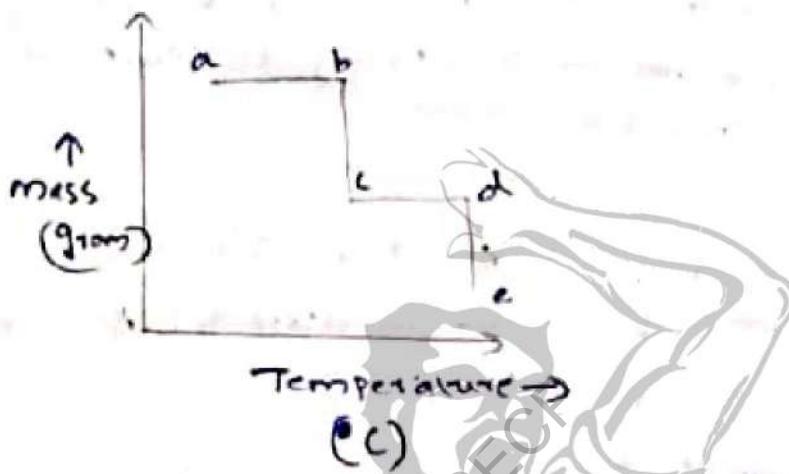


Applications.

- 1) used in molecular weight determination
- 2) used in the field of water purification
- 3) helps in detection of impurities in pharmaceutical industries.
- 4) in the analysis of herbal products.

(b) TGA represents The thermogravimetric analysis, here the physical & chemical properties of the material are measured as a function of temperature. During this the substance may loose weight due to reduction, decomposition etc ... or gain weight due to oxidation, adsorption etc ..

The Thermogram It is a plot drawn between Temperature & mass.



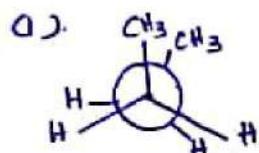
This graph has 2 parts (horizontal part like ab, cd)
& (vertically downward part like bc, de), etc ..

From the graph it is clear that,

In the horizontal part of graph the mass does not vary with change in temperature, this indicates the thermal stability of that compound & is very useful to engineers because it reveals the temperature range in which the substance like Polymers, packing materials, alloys etc .. may be safely used.

17. a.

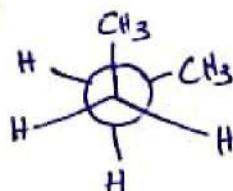
Conformations in butane:-



This conformation has dihedral angle = 0°

Since this is eclipsed with both CH₃ groups so close or they come in front, this form is really unstable and possesses high energy.

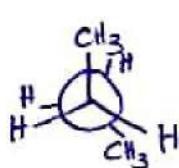
(2)



Dihedral angle = 60°

It has lower energy since it is staggered.

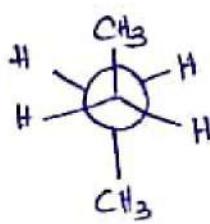
(3)



Dihedral angle = 120°

This conformation possess high energy since it is eclipsed, but not as high as (1)

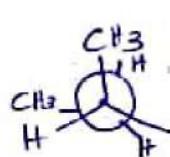
(4)



Dihedral angle = 180°

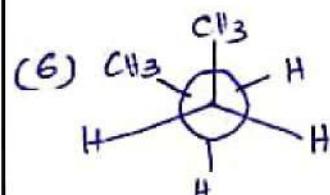
Not only is it a staggered structure, it is also having two CH₃ groups as far apart as possible. Hence is really stable and low energy.

(5)



Dihedral angle = 240°

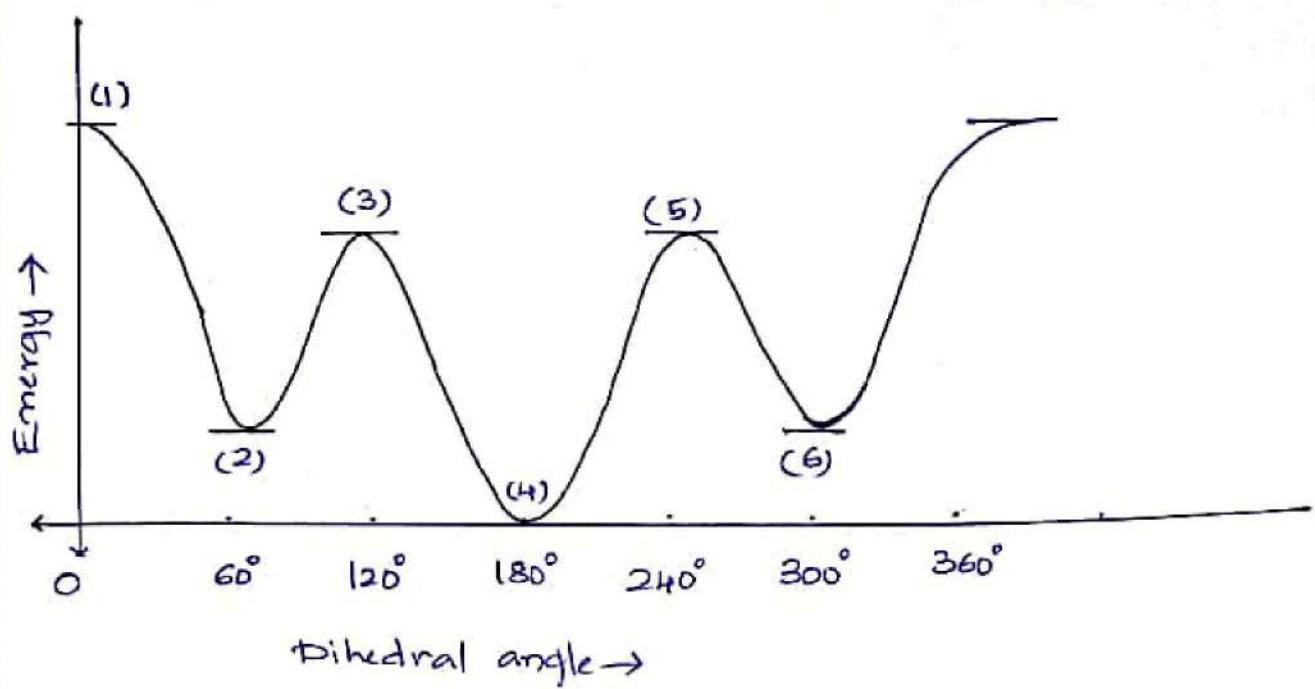
This is degenerate with (3)



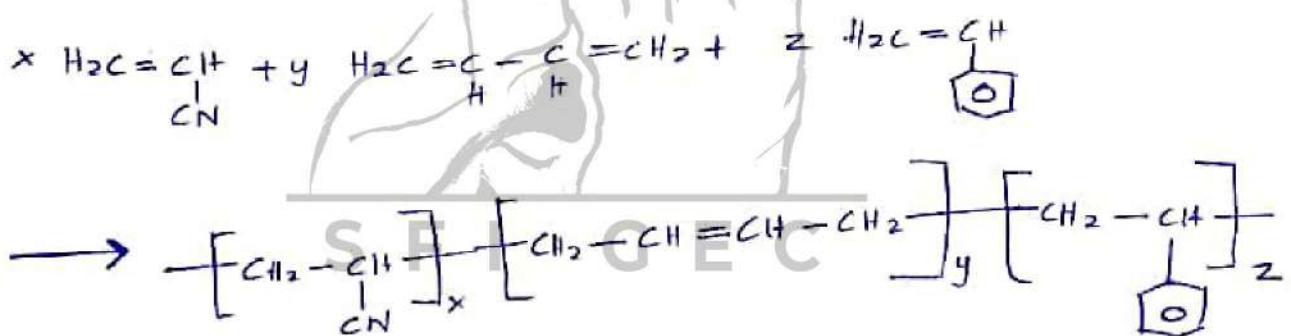
Dihedral angle = 300°

This conformation is degenerate with (2)

And eventually, dihedral angle = 360° will be same as (1)



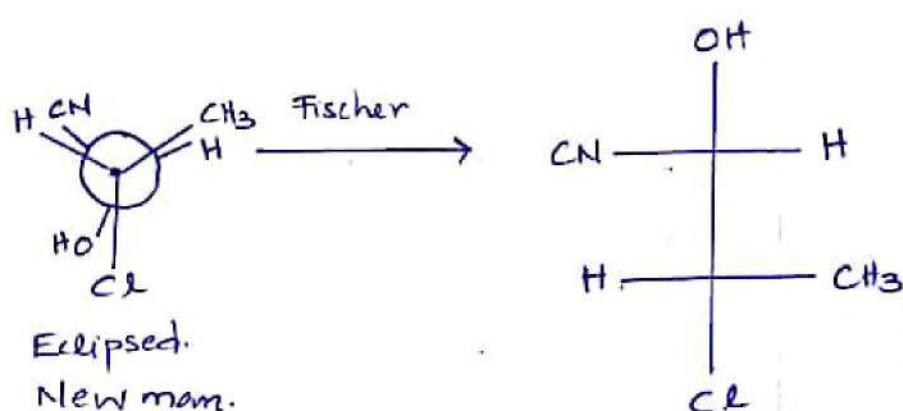
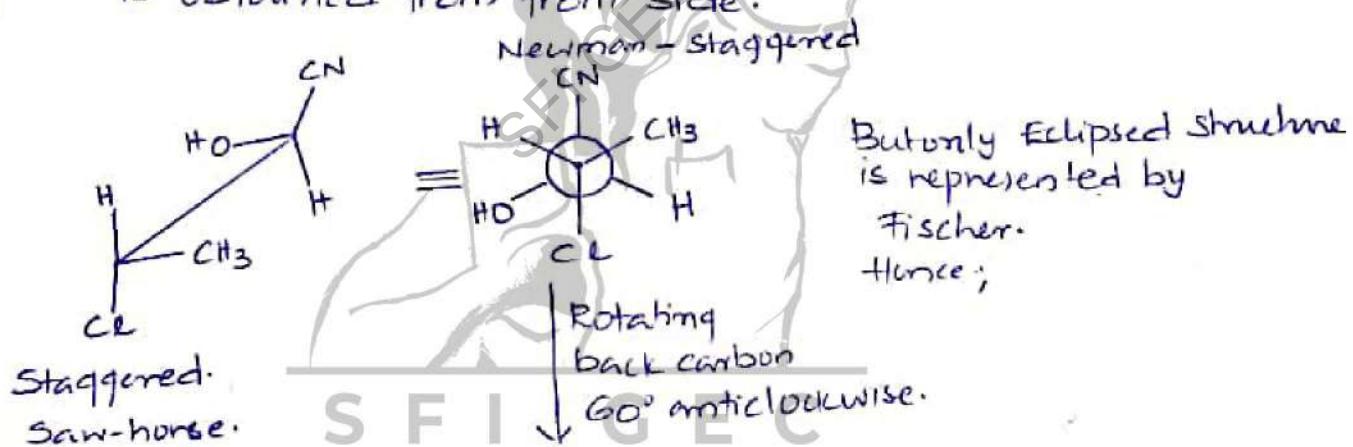
b) ABS (Acrylonitrile, Butadiene Styrene) is a terpolymer made by polymerizing styrene and acrylonitrile in the presence of poly butadiene. proportions vary between 15-35% acrylonitrile, 5-30% butadiene and 40-60% styrene. It is a long chain of poly butadiene blocks cross-crossed with random shorter chains of poly (styrene-Co-acrylonitrile).

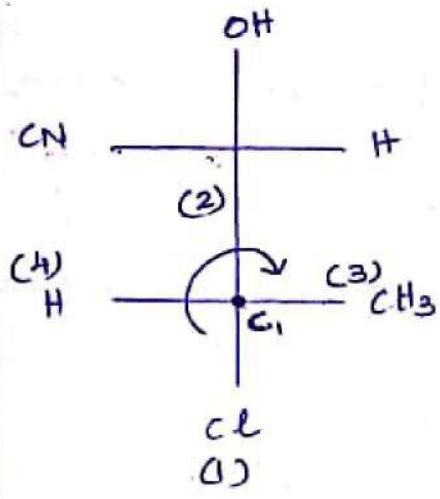


- Applications include manufacturing of products such as TV cabinets, computer monitor body, kitchen appliances etc. It is also used in automobile industry for making trim components, bumper bars etc. It is also used to manufacture medical devices for blood access, enclosures for electrical and electronics assemblies, household and consumer goods etc.

18 a. Rules for assigning R and S configuration:-

- * 1. Directly attached atoms having highest atomic number have highest priority.
- * 2. When two directly attached atoms are same, look for the atomic number of the next linked atom.
- * 3. For double bonds like $-C=O$, $-C=C$ are treated as two oxygen attachment and two carbon attachment, respectively to first carbon atom.
- * 4. Molecule is viewed such that lowest priority group is away from us and look for priority order.
Clockwise \Rightarrow R. & Anticlockwise \Rightarrow S.
- * 5. If the lowest priority group given in a structure is towards us, take opposite i.e. opposite rotation of what is obtained from front side.





For C₁, Cl has highest atomic no. and hence 1st priority.

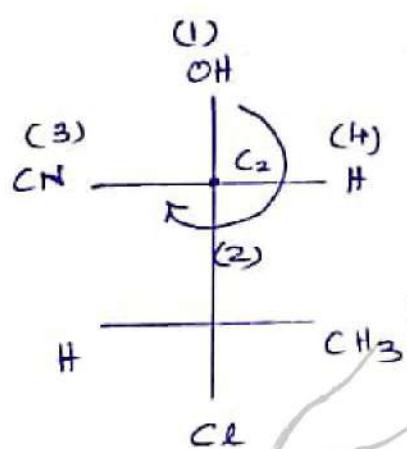
out of CH₃ and other group,

In CH₃, C attached to 3 H while in the other C connected to another C and O.

Hence CH₃ = priority 3 and 'H' is priority 4.

From the figure C₁ asymmetrical carbon is clockwise and hence R. But lowest priority 'H' is on horizontal and hence towards us. Thus the configuration is actually reversed.

Hence C₁ = S



In case of C₂, OH is of highest priority.

out of CN and CHCl(CH₃),

In CN, C connected to N and in Other C connected to Cl.

Hence CHCl(CH₃) = priority 2
CN = priority 3 and H = 4.

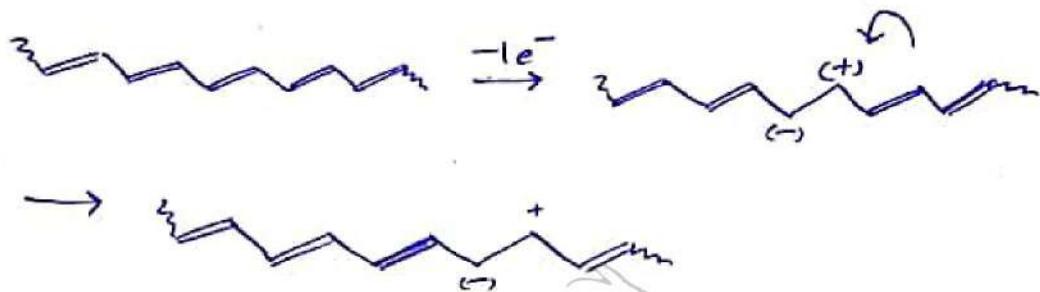
As we can see, for C₂, direction is anticlockwise and hence S. But again lowest priority is on horizontal and hence original configuration of C₂ = R

- b. The conductivities of conducting polymers can be increased by creating positive and negative charge on polymer backbone by oxidation or reduction. This process is referred to as doping.

Doping is of two types, P and n.

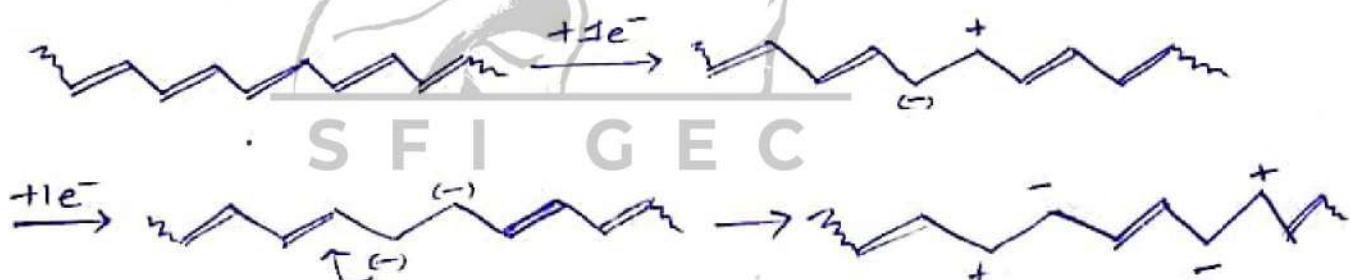
P doping:-

P doping is done by oxidation process. In this process, some e^- from conjugated double bonds are removed and the holes so created can move around. i.e. the polymer becomes electrically conductive. The radical cation hence produced is called polaron. The oxidation process is generally brought about by Lewis acids such as $TiCl_3$.



n doping:-

Here, some e^- are introduced into polymer having conjugated double bonds by reduction with Lewis bases like lithium sodium naphthalide etc. The reduction of polyacetylene polymer by Lewis base leads to formation of anion called 'Polaran' and bipolarons in two steps as depicted in eq of polyacetylene.



19.(a)

MUNICIPAL WATER TREATMENT:

It refers to the sequence of processes which are employed in purifying the municipal water for domestic purposes. It primarily involves two steps. Removal of suspended impurities and removal of micro organisms.

I. Removal of suspended impurities:

The various steps involved in this process are

- a) Screening: Large, floating impurities are removed when raw water is passed through screens with large number of holes.
- b) Aeration: Done by bubbling air in water using aeration pumps. Brings air and water in close contact. Helps in removing dissolved gases and oxidises dissolved metals like iron, as well hydrogen sulfide, volatile organic compounds etc.
- c) Sedimentation: Water is allowed to stand undisturbed in big tanks for 2-6 hours to remove suspended particles with the help of gravity. Supernatant water can be pumped out. If the water contains colloidal particles, coagulants are added to supplement sedimentation.
- d) Filtration: Water passes through fine sand and other granular materials. To remove bacteria, micro organisms ~~left~~ lodged in colloidal material can be removed.

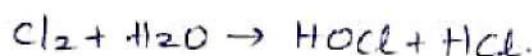
2. Removal of micro Organisms: (Disinfection)

Killing the pathogenic bacteria and micro-organisms from water to make it safe for use.

Disinfection can be done using multiple ways:

(a) Chlorination:

Chlorine, when added to water in concentrated liquid or gaseous forms will produce HOCl.



Chlorinator is the device used for chlorination and contains a number of baffle plates which will help mix chlorine & water well to produce disinfection effect.

Types of chlorination:-

* Breakpoint chlorination & Dechlorination:-

It involves addition of chlorine in amounts enough to kill all micro organisms and destroy it completely. by oxidation. Organic matter, reducing agents, colouring material, free ammonia etc. will also get destroyed.

De chlorination is the process of passing break point chlorinated water via bed of molecular carbon or adding activated carbon, small % of sulphur dioxide, sodium sulphite, sodium thiosulphate (any one) etc. to remove excess chlorine which will leave behind odour and taste.

* Using chloramine:

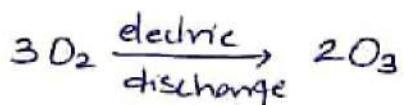
Chloramine can be produced by mixing NH_3 and Cl_2 in 1:2 proportion by volume. It can be added to H_2O to produce HOCl. Chloramine is long lasting compared to pure chlorine and hence much more efficient. It doesn't produce odour and gives good taste.

* Using bleaching powder:

Used in small scale applications. Added at a rate of 1 kg / 1000 kilolitres. Produces HClO which causes disinfection.

b) Using Ozone:

Ozone is an excellent disinfectant and used in gaseous form. It is produced by passing silent electric discharge through cold and dry O₂.



It removes colour, odour & taste, but is really expensive.

c) Using UV :

Ultraviolet light can be obtained by passing current in mercury lamp enclosed in quartz globe. UV has good disinfectant action and kills all bacteria. It leaves no taste or odour behind, but is really costly and requires technical expertise. It is mainly employed in swimming pools and drinking water purifiers.

S F I G E C

These are the steps involved in municipal water treatment along with a brief description of the ways in which these steps can be successfully achieved.

- b). Given Sample of Standard hard water has 5 g/L CaCO_3 .
- Normality of standard hard water = No. of equivalents/Litre
 $= \frac{5}{50} = \underline{\underline{0.1 \text{ N}}}$

- Concentration of EDTA Solution can be calculated from data(i). which states that

$$20 \text{ mL } 0.1 \text{ N Water (standard)} \equiv 25 \text{ mL } N_1 \text{ EDTA soln.}$$

$$\therefore N_1 = \frac{20 \times 0.1}{25} = \underline{\underline{0.08 \text{ N}}}$$

- Total hardness of water sample can be calculated from data (ii) which states that

$$24 \text{ mL } 0.08 \text{ N EDTA} \equiv 100 \text{ mL } N_2 \text{ water sample.}$$

$$\text{Now } N_2 = \frac{24 \times 0.08}{100} = \underline{\underline{0.0192 \text{ N}}}$$

In order to represent this in CaCO_3 equivalents, and in ppm.

$$0.0192 \times 50 \times 1000 \xrightarrow{\substack{\text{To convert into} \\ \text{mg/L}}} = \underline{\underline{960 \text{ ppm}}}$$

$\xrightarrow{\substack{\text{To convert into} \\ \text{CaCO}_3 \text{ eq.}}}$

- Permanent hardness can be calculated from data(iii) which states that

$$18 \text{ mL } 0.08 \text{ N EDTA} \equiv 100 \text{ mL } N_3 \text{ water sample after boiling.}$$

$$N_3 = \frac{18 \times 0.08}{100} = \underline{\underline{0.0144 \text{ N}}}$$

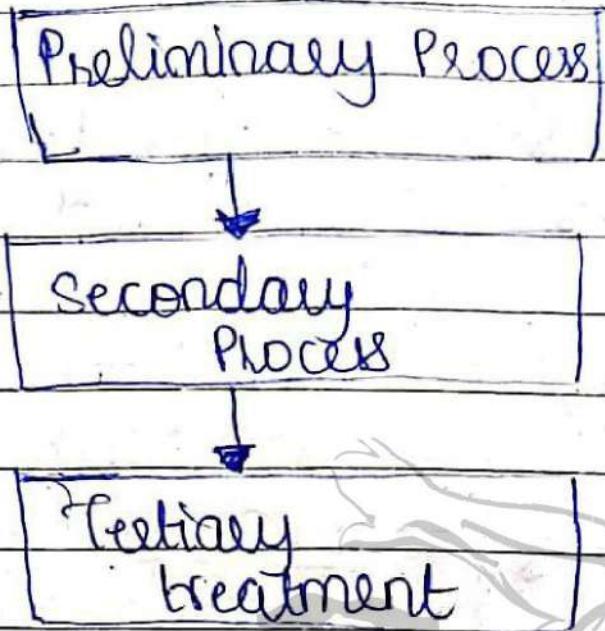
Converting to CaCO_3 equivalent in ppm;

$$0.0144 \times 50 \times 1000 = \underline{\underline{720 \text{ ppm}}} = \text{permanent hardness}$$

$$\begin{aligned} \text{Temporary hardness} &= \text{Total hardness} - \text{permanent hardness} \\ &= 960 - 720 = \underline{\underline{240 \text{ ppm}}} \end{aligned}$$

\therefore Given Water Sample has temporary hardness of 240 ppm and permanent hardness of 720 ppm.

20) a) Sewage Treatment



i) Preliminary Process

* Screening

→ sewage is passed through bar & mesh screens.

→ large solid impurities suspended in the sewage are removed

* Sedimentation

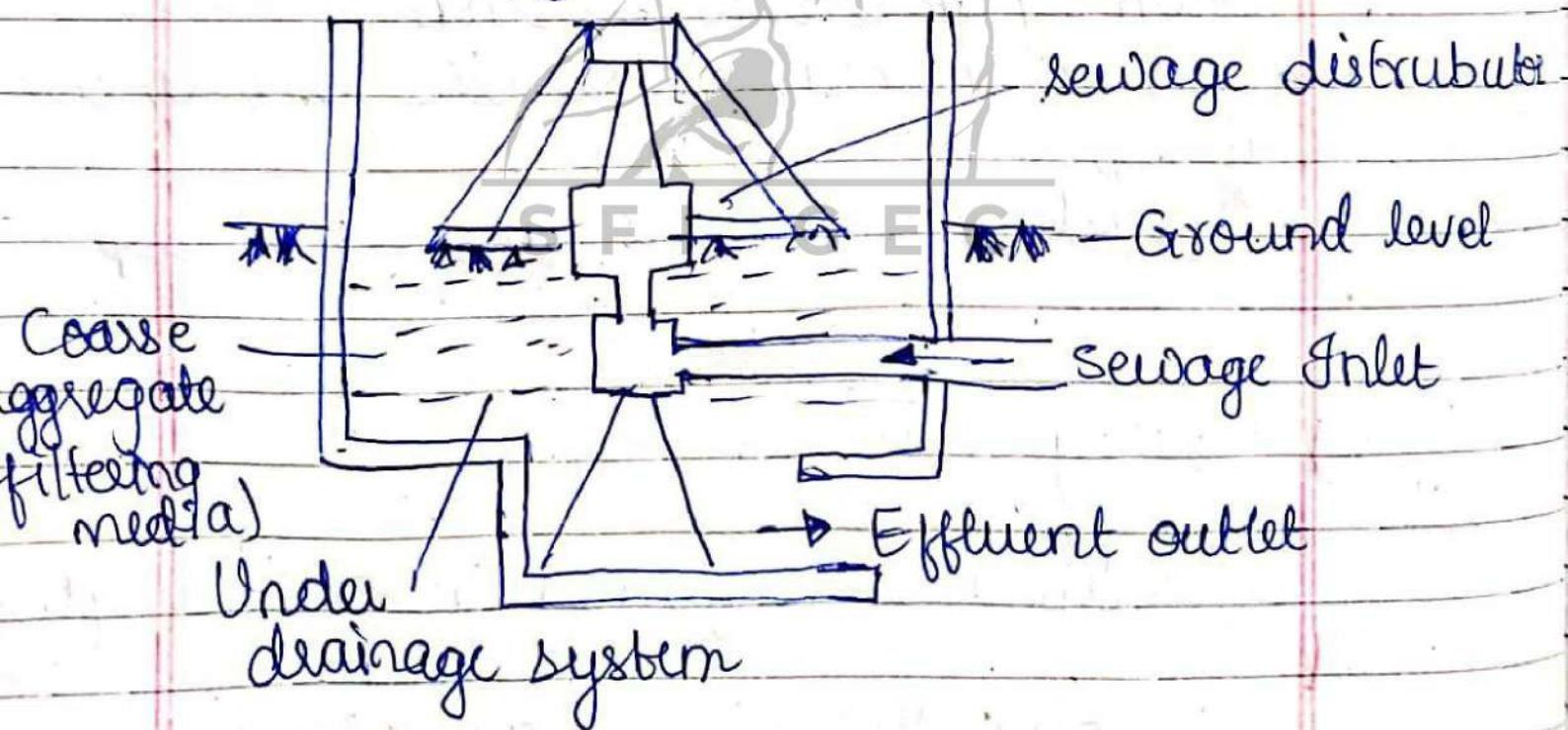
→ Continuous flow type sedimentation tanks employed, suspended impurities removed

→ Coagulants (Alum) are added to sewage before sedimentation to entrap small organic impurities and form gelatinous ppt.

ii) Secondary Process / Biological Process

a) Trickling filter method (Aerobic filtration)

- Aerobic oxidn. of sewage, conversion of Carbon $\rightarrow \text{CO}_2$, $\text{N}_2 \rightarrow \text{NH}_3$ & finally nitrates & nitrates
- The filter is in rectangular shape, 2m depth
- It is filled with materials like broken bricks, crushed rocks, etc & fitted with a rotating distributor which delivers sewage.
- Organic matter present in the sewage is consumed by aerobic microorganism.



b) Upflow Anaerobic Sludge Bed Reactor (UASB)

- Wastewater enters the reactor from below & flows upwards

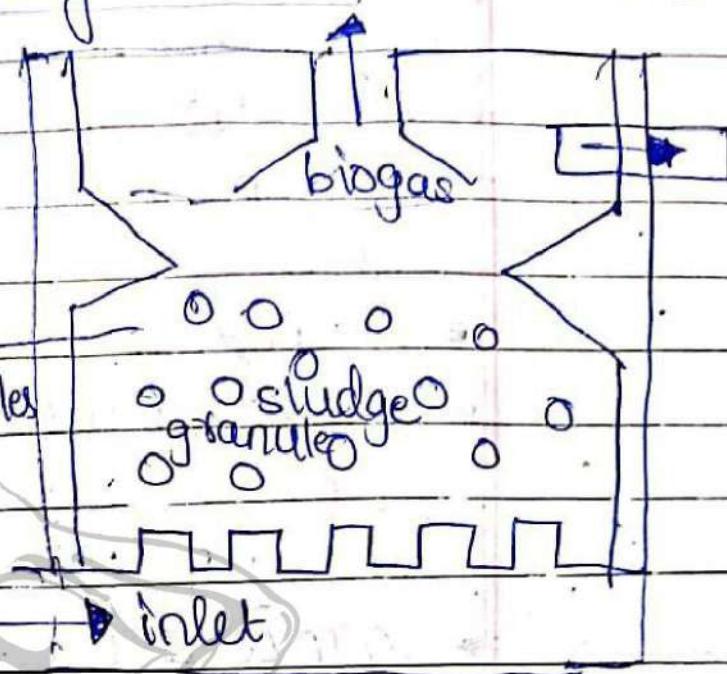
- Water passes through an anaerobic sludge gas blanket.

- Microbes in sludge get in contact with water substrate

- Organic matter is broken down by anaerobic digestion

- Biogas methane is collected and removed at top

- Treated wastewater is removed at top



iii) Tertiary treatment

3 steps involved are:

a) Precipitation - Effluent + $\text{CaO} \rightarrow \text{Ca Phosphate (PPT)}$

b) Nitrogen Stripping - NH_3 gas is removed by passing effluent through a series of baffle plates

c) Chlorination - Disinfection of sewage is done by treating with Cl_2

$$20) b) \text{Ca}(\text{HCO}_3)_2 = 28 \text{ mg/l}; \text{CaSO}_4 = 18 \text{ mg/l}, \\ \text{Mg}(\text{CHCO}_3)_2 = 32 \text{ mg/l}, \text{MgCl}_2 = 30 \text{ mg/l}, \\ \text{NaCl} = 58 \text{ mg/l}$$

Temporary Hardness ($\text{Ca}(\text{HCO}_3)_2, \text{Mg}(\text{CHCO}_3)_2$)

$$\text{Ca}(\text{HCO}_3)_2 \rightarrow \text{Molecular wt} = 40 + 2 \times (1+12+48) \\ = 162 \text{ g/mol}$$

$$\text{Eq. wt} = \frac{162}{2} = 81 \text{ g/mol}$$

$$\text{Mg}(\text{CHCO}_3)_2 \rightarrow \text{Molecular wt} = 24 + 2 \times 61 = 146 \text{ g/mol}$$

$$\text{Eq. wt} = \frac{146}{2} = 73 \text{ g/mol}$$

$$\text{Temporary Hardness} = 28 \times \frac{50}{81} + 32 \times \frac{50}{73} \\ = 39.1 \text{ ppm}$$

Permanent Hardness ($\text{MgCl}_2, \text{CaSO}_4$)

$$\text{MgCl}_2 (\text{molar wt}) = 24 + 2 \times 35.5 = 95 \text{ g/mol}$$

$$\text{CaSO}_4 (\text{molar wt}) = 40 + 32 + 16 \times 4 = 136 \text{ g/mol}$$

$$\text{Permanent hardness} = 30 \times \frac{50}{95.5} + 18 \times \frac{50}{68} \\ = 44.81 \text{ ppm}$$

$$\boxed{\text{Eq. wt} = \frac{\text{Molecular wt}}{2}}$$