Internal Assessment Test 2 – March 2023

Sub:	Chemistry					Sub Code:	BCHEE102	Branch:	ECE	
Date:	03-03-2023	Duration:	90 min's	Max Marks:	50	Sem / Sec:	I / M, N, O & P			OBE

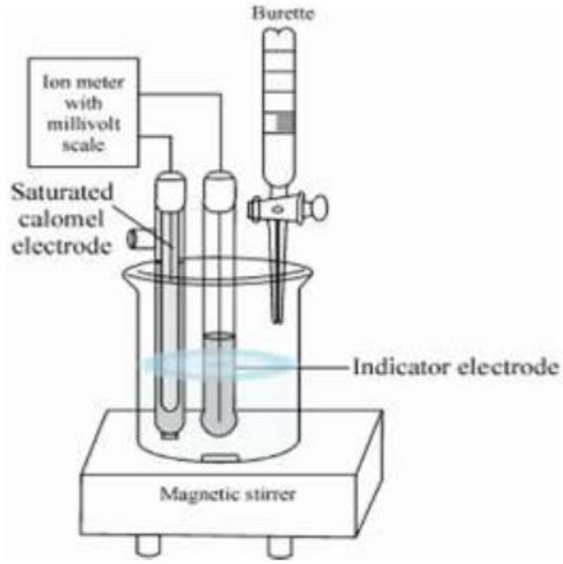
			MARKS	CO	RBT
		Question no. 1 is COMPULSORY and answer any THREE FULL Questions from the rest.			
1	(a)	Explain the principle and instrumentation of potentiometric sensors and its application in the estimation of iron.	[7]	CO4	L3
	(b)	Define electroless plating. Illustrate the electroless plating of copper in the manufacture of double-sided PCB with suitable reactions.	[7]	CO3	L3
2	(a)	What are reference electrodes? Describe the construction and working of a calomel electrode.	[6]	CO3	L2
	(b)	Explain the principle and instrumentation of colorimetric sensors and its application in the estimation of copper.	[6]	CO4	L3
3	(a)	What are conducting polymers? Explain the preparation and conducting mechanism of polyacetylene. Mention its commercial applications.	[6]	CO1	L3
	(b)	In a polymer sample, 45% of molecules have molecular mass of 18000 g/mol, 30% molecules have molecular mass of 25000 g/mol, and remaining molecules have molecular mass of 30000 g /mol, calculate the number average and weight average molecular masses of the polymer.	[6]	CO1	L2

4 (a)	What are electrochemical sensors? Explain their working principle and applications.	[6]	CO4	L3
(b)	What are thermometric sensors? Describe their working principle and applications.	[6]	CO4	L2
5(a)	What are concentration cell? The cell potential of copper concentration cell $Cu/CuSO_4(0.002M)//CuSO_4(xM)/Cu$ is 0.0350 at 40°C. Calculate the value of x. Given R = 8.314 $Jmol^{-1}K^{-1}$ and F = 96500 C/mol, Also write the cell reactions.	[6]	CO3	L3
(b)	What are ion selective electrodes? Explain the construction and working of glass electrode.	[6]	CO3	L3
6 (a)	Describe the production of electronic grade silicon by Czochralski (CZ) process.	[6]	CO1	L2
(b)	Define conductors, semiconductors, and insulators, and mention the differences between these using band theory.	[6]	CO1	L2
7 (a)	Explain the principle and instrumentation of conductometric sensors and its applications in the estimation of weak acid.	[6]	CO4	L3
(b)	Discuss the preparation, properties and commercial applications of graphene oxide.	[6]	CO1	L2

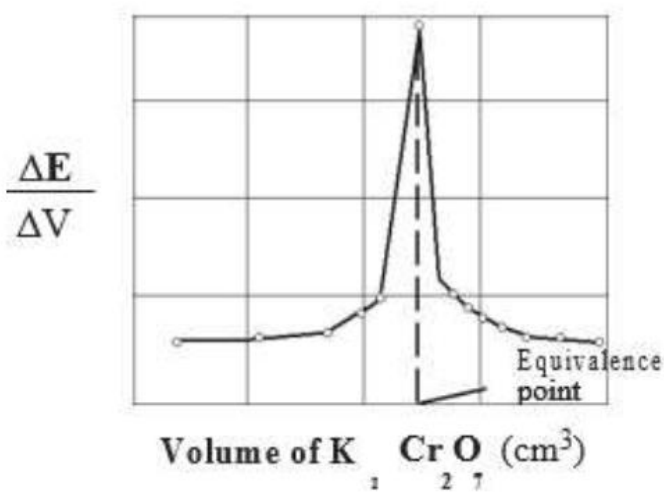
Answer 1a **Principle:** The procedure of using measurement of emf to determine the concentration of ionic species in solution is called as potentiometry also known as potentiometric titration. When a metal M is immersed in a solution containing its own ions M^{n+}, the electrode potential is
given by Nernst equation.

$$E = E^{o} + \frac{0.0591}{n} \log [M^{n+}]$$

Thus, the concentration can be calculated, provided E^{o} of the electrode is known. The principle involved in potentiometric titration is the measurement of emf between two electrodes, an indicator electrode, (the potential of which is function of the concentration of the ion to be determined) and a reference electrode of constant potential. In this method, the measurement of emf is made while the titration is in progress. The equivalence point of the reaction is revealed by a sudden change in potential in the plot of emf readings against the volume of titrant.
Instrumentation: A potentiometer consists of: (i) Calomel electrode as a reference electrode, (ii) Platinum electrode as an indicator electrode, (iii) a device for measuring the potential and (iv) Magnetic stirrer.



Application: Potentiometric estimation of FAS using standard $K_2Cr_2O_7$ solution: Pipette out 25ml of FAS into a beaker. Add 1 t.t dil H_2SO_4, immerse calomel electrode + platinum electrode into it. Connect the assembly to a potentiometer and measure the potential by adding $K_2Cr_2O_7$ in the increments of 0.5ml. Plot graph $\Delta E/\Delta V$ against volume of $K_2Cr_2O_7$, and determine the equivalence point. From the normality and volume $K_2Cr_2O_7$, solutions calculate the normality and the weight of FAS in the given solution.



Answer 1b. Electroless plating is the controlled deposition of a continuous film of a metal from its salt solution on a catalytically active surface of the substrate by a suitable reducing agent, without the use of electrical energy.

Electroless-plating of Copper on PCB

Activation of surface: The base of a printed circuit board is a plastic material such as epoxy or phenolic polymer or a glass fiber reinforced polymer composite. It is activated by treatment with acidified $SnCl_2$ and then with acidified $PdCl_2$ leads to deposition of Pd.

$SnCl_2 + PdCl_2 \rightarrow Pd + SnCl_4$

In the manufacture of double sided PCB, the board is clad on either side with thin electroformed copper foils. Then both sides of the copper clad board are printed with etch-resistant circuit patterns. Rest of the unprotected copper foil is etched (formation of tracks) away by using an acid. This leaves only the circuit patterns on both sides of the board. Electrical connection between the two sides of PCB is made by drilling a hole through the board. The hole is then activated & electroless plated with copper, as it can't be electroplated. The composition of the electroless plating bath & the procedure given below.

Constituents	Purpose
$CuSO_4$	Provides metal ions
HCHO	Reducing reagent
Rochelle salt	Complexing agent
NaOH	Provides alkaline medium
EDTA	Exaltant & complexing agent
pH	11.0
Temperature	25°C

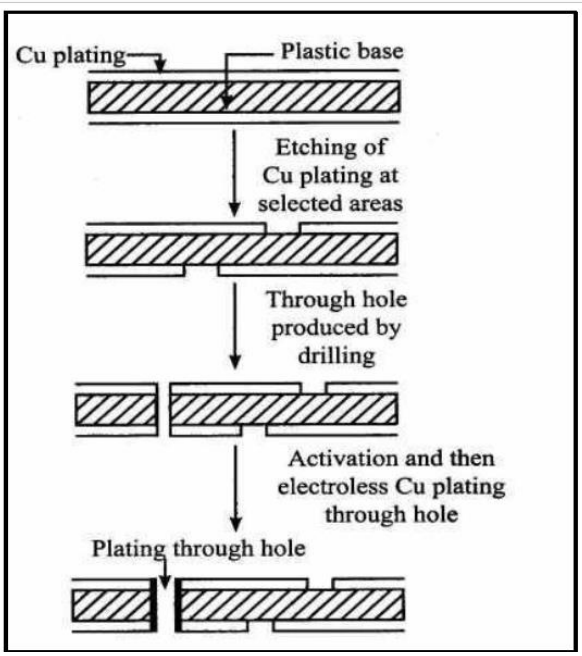
Following reactions takes place during the process:

Reactions:

Oxidation of reducing reagent : $2HCHO + 4OH^- \longrightarrow 2HCOO^- + 2H_2O + H_2 + 2e^-$

Reduction of metal ion over object surface : $Cu^{2+} + 2e^- \longrightarrow Cu$

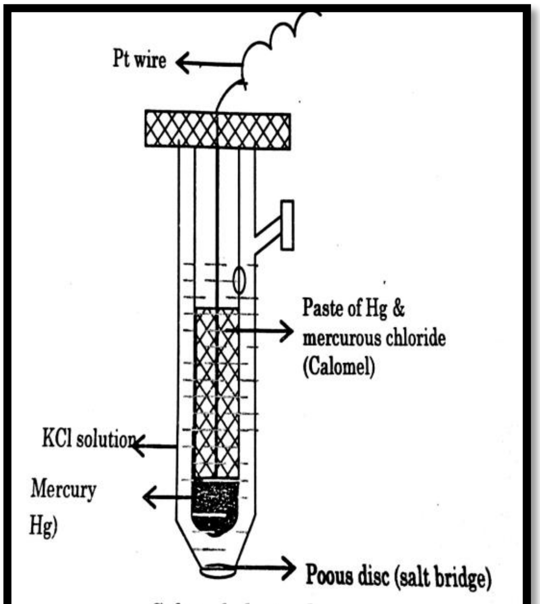
Overall reaction : $Cu^{2+} + 2HCHO + 4OH^- \longrightarrow Cu + 2HCOO^- + 2H_2O + H_2\uparrow$



Answer 2a. **Reference Electrodes**

Reference electrodes are the electrodes whose potentials are known and they are used for the determination of potentials of other electrodes.
Calomel electrode: It is a metal – metal salt ion electrodes and also a secondary reference electrode.

Construction: It consists of mercury, mercurous chloride and a solution of KCl. It is made up of glass tube, Hg is placed at the bottom of the glass tube. It is covered with a paste of calomel ($HgCl_2$) and KCl solution. A solution of KCl is introduced above the paste through the side tube. Electrical contact is made through Pt wire (dipped in Hg). This glass tube is taken into another glass tube, which has a side tube and a porous plug at the bottom. This porous plug act as salt bridge. The conc of KCl solution used is either decinormal, normal or saturated. Correspondingly, the electrode is known as decinormal, normal or saturated calomel electrode. This constitutes one half cell. Calomel electrode can act as either anode or cathode. It is connected to the other half cell through salt bridge.



Calomel electrode

Half cell representation

The calomel electrode is represented as, $Hg / Hg_2Cl_2 (s) / Cl^-$ (anode)

Or $Cl^- / Hg_2Cl_2 (s) / Hg$ (Cathode)

Working: Depending on the potential of electrode with which the calomel electrode is connected, calomel electrode acts as anode or cathode.

(a). When it acts as anode, electrode reaction is

$$2Hg \longrightarrow Hg_2^{2+} + 2e^-$$

$$Hg_2^{2+} + 2Cl^- \longrightarrow Hg_2Cl_2$$

$$2Hg + 2Cl^- \longrightarrow Hg_2Cl_2 + 2e^-$$

(b) When it acts as cathode, electrode reaction is

$$Hg_2^{2+} + 2e^- \longrightarrow 2Hg$$

$$Hg_2Cl_2 \longrightarrow Hg_2^{2+} + 2Cl^-$$

$$Hg_2Cl_2 + 2e^- \longrightarrow 2Hg + 2Cl^-$$

Thus, Net reversible electrode reaction is

$$Hg_2Cl_2 + 2e^- \rightleftharpoons 2Hg + 2Cl^-$$

Electrode potential is calculated using Nernst equation,

$$E_{cal} = E^\circ - \frac{2.303RT}{2F} \log [Cl^-]^2$$

Applications:

1. It is used as secondary reference electrode in all potentiometric determinations.
2. Used in glass or combined electrode to determine the pH of the unknown solution.

Answer 2b. **Principle:** Colorimetry is a scientific technique that is used to determine the concentration of colored compounds in solutions.

When a beam of incident light of intensity $\mathbf{I_0}$ passes through a solution, a part of the incident light is relected ($\mathbf{I_r}$), a part is absorbed ($\mathbf{I_a}$) and rest of the light is transmitted ($\mathbf{I_t}$)

Thus, $\mathbf{I_0 = I_r + I_a + I_t}$

In colorimeter, $\mathbf{I_r}$ is eliminated. For this purpose, the amount of light relected ($\mathbf{I_r}$) is kept constant by using cells that have identical properties. ($\mathbf{I_0}$) & ($\mathbf{I_t}$) is then measured. Colorimetry measurements are based on Beer-Lambert's law which states that when a monochromatic light passes through a transparent medium, the amount of light absorbed is directly proportional to the concentration and path length of the solution.

$$\mathbf{A = \varepsilon ct}$$

Where A is absorbance, ε is the molar extinction coefficient, c is the concentration, t is the path length. If t, the path length is kept constant, then, $A \propto c$. Hence a plot of absorbance against concentration gives a straight line.

Instrumentation: Photoelectric colorimeter consists of

(i) Tungsten lamp as the light source.

(ii) A filter which provides the desired wavelength range wherein the solution gives the maximum absorbance.

(iii) A sample cell
(iv) A photocell detector: Detector are photosensitive elements which converts light energy into electrical energy

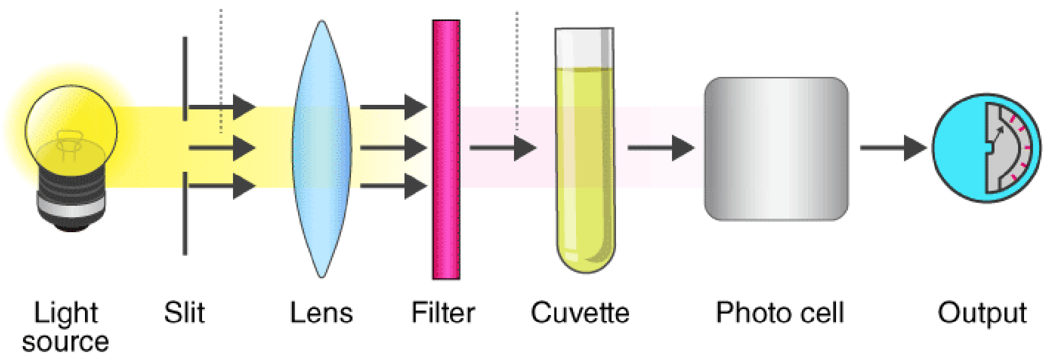
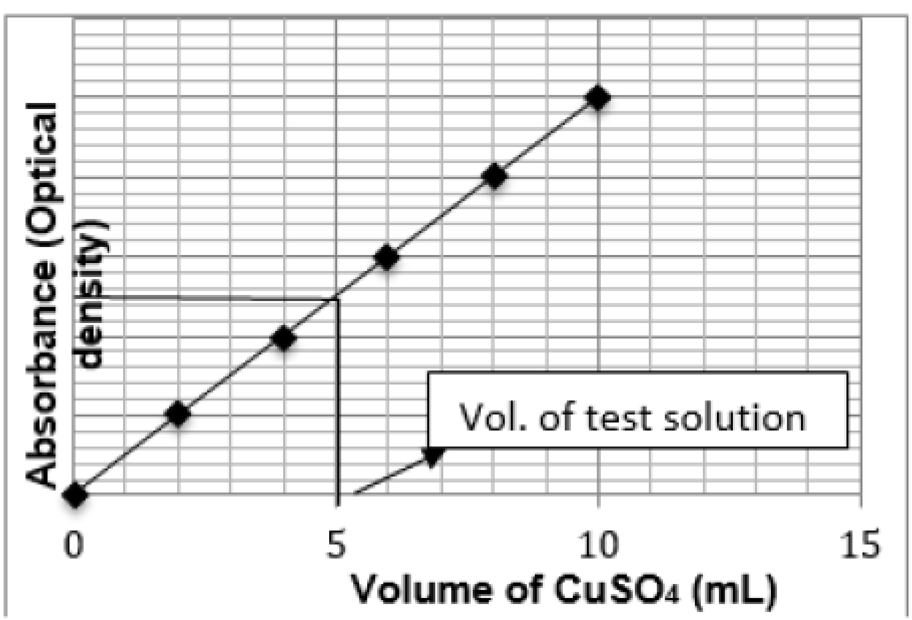
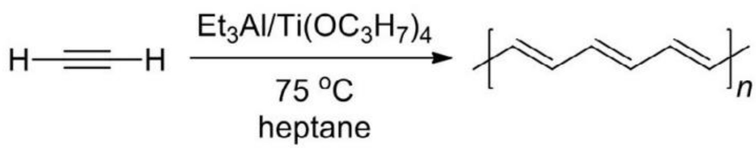


Fig: Schematic layout of colorimeter

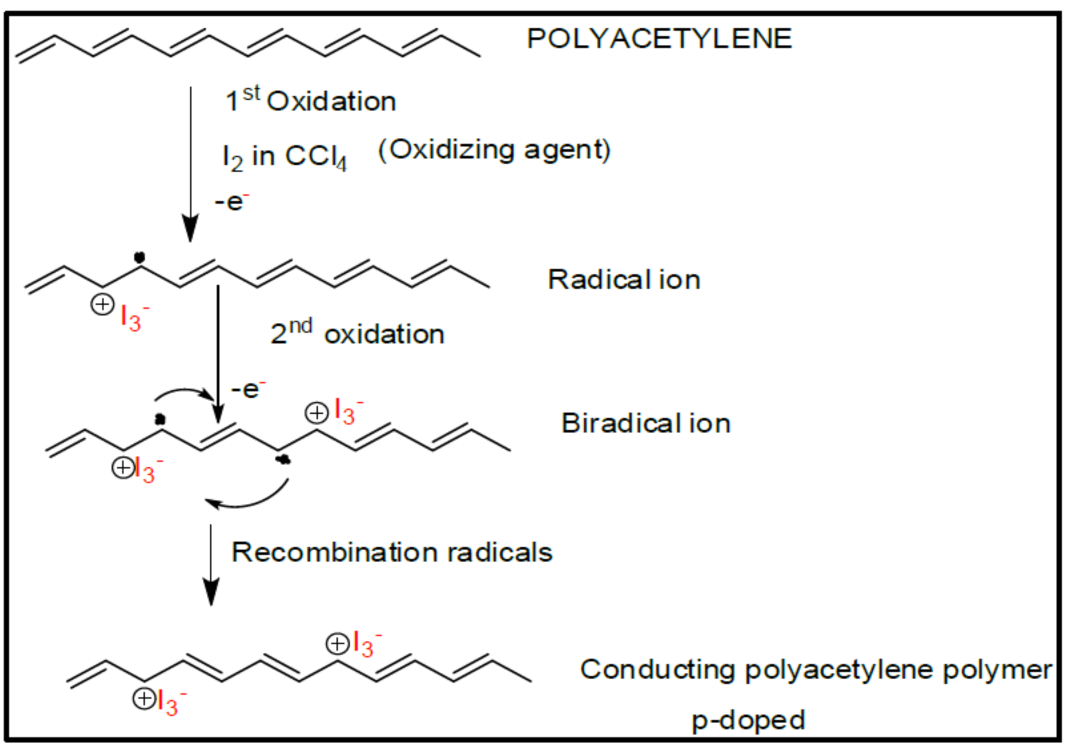
Application: Colorimetric estimation of Cu in $CuSO_4$. Draw out 2, 4, 6, 8, and 10 ml cm_3 of the Copper sulphate solution into $50cm_3$ volumetric flask. Add $5cm_3$ of ammonia solution to each of them and dilute upto the mark with distilled water and mix well. Prepare a blank solution by diluting $5cm^3$ of ammonia solution in $50cm^3$ volumetric flasks. For test solution add 5ml of NH_3 and make up to the mark. Measure the absorbance of each of these against blank solution at 620 nm. Plot a graph of absorbance (OD) against volume of copper sulphate solution and determine the volume of copper sulphate solution in the test sample as shown in the figure and find the amount of copper present in it.



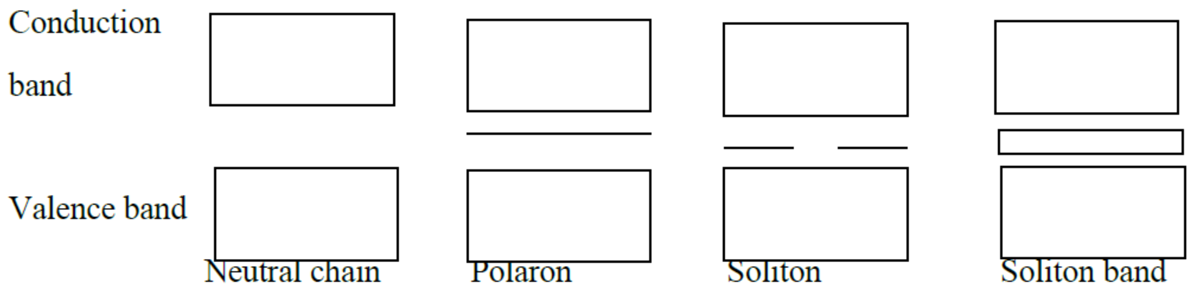
Answer 3a. Polymers which can conduct electricity are called conducting polymers.
Synthesis of polyacetylene:
A variety of methods have been developed to synthesize polyacetylene, from pure acetylene and other monomers. One of the most common methods uses a Ziegler–Natta catalyst, such as Et_3Al / $Ti(OC_3H_7)_4$ with gaseous acetylene. This method allows control over the structure and properties of the final polymer by varying temperature and catalyst.



Mechanism of conduction in polyacetylene:
(i) By Oxidative doping (p-doping): In this process, π-back bone of polymer is partially oxidized using a suitable oxidizing agent such as I_2 in CCl_4. The removal of an electron from the polymer π-back bone leads to the formation of delocalized radical ion called polaron. A second oxidation of chain containing polaron produces bipolaron which on radical recombination yields two charge carries on each chain. The positive charge sites on the polymer chain are compensated by anion I_3^- formed by the oxidizing agent during doping. The delocalized positive charges on the polymer chain are mobile, not the dopant anions. Thus these delocalized positive charges are current carriers for conduction. These charges must move from chain to chain as well as along the chain for bulk conduction .
(v) On doping polyacetylene using I_2 in CCl_4, the conductivity increases from 10^{-5} S cm^{-1} to 10^{3}-10^{5} S cm^{-1}.



If polyacetylene is heavily doped, polarons form pairs called solitons. In polyacetylenes the solitons are delocalized over 12 carbon atoms. Due to the formation of soliton, a new localized electronic state appears in the middle of the energy gap. When the doping is high, several charged solitons form soliton band. This band can later merge with edges of valence and conduction bands thus exhibiting conductivity.



Application of polyacetylene: .
The most extensively studied and is widely investigated computationally and experimentally for use in electronic devices such as light-emitting diodes, water purification devices, hydrogen storage, and biosensors.

Answer 3b. **Solution:**

Number average molecular weight = $\dfrac{N_1M_1 + N_2M_2 + N_3M_3}{N_1 + N_2 + N_3}$

$= \dfrac{(45 \times 18000) + (30 \times 25000) + (25 \times 30000)}{45+30+25}$

= 23100 g/mol

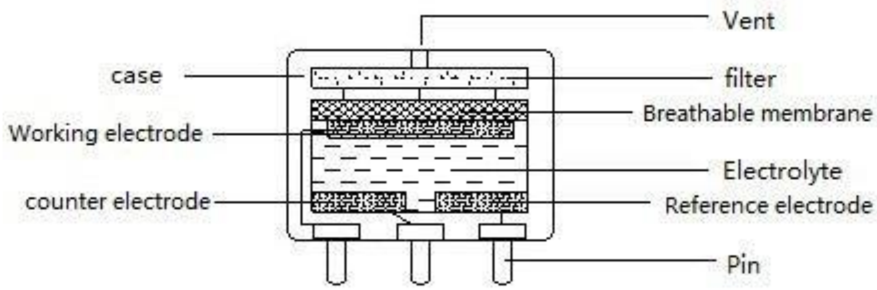
Weight average molecular weight = $\dfrac{N_1M_1^2 + N_2M_2^2 + N_3M_3^2}{N_1M_1 + N_2M_2 + N_3M_3}$

$= \dfrac{(45 \times 18000 \times 18000) + (30 \times 25000 \times 25000) + (25 \times 30000 \times 30000)}{(45 \times 18000) + (30 \times 25000) + (25 \times 30000)}$

= 24168.8 g/mol

Answer 4a. Electrochemical sensors are devices that give information about the composition of a system in real time by coupling a chemically selective layer (the recognition element) to an electrochemical transducer. **Electrochemical sensors** are made on the basis of ion conduction. According to the formation of their electrical characteristics, electrochemical sensors can be divided into potential sensors, conductivity sensors, electricity sensors, polarographic sensors, and electrolytic sensors. Electrochemical sensors are mainly used to analyze gas, liquid, or solid components dissolved in liquids, the measurement of liquid pH, conductivity, and oxidation-reduction potential.

Working Principle: The electrochemical sensor works by reacting with the measured gas and generating an electric signal proportional to the gas concentration. A typical electrochemical sensor consists of a sensing electrode and a counter electrode and is separated by a thin electrolytic layer.



The gas first reacts with the sensor through the tiny capillary-shaped opening, then the hydrophobic barrier layer, and finally reaches the electrode surface. Using this method can allow an appropriate amount of gas to react with the sensing electrode to form a sufficient electrical signal while preventing electrolytes from leaking out of the sensor. The electrochemical sensor contains the following main components:

a) **Breathable membrane** (also called hydrophobic membrane): The breathable membrane is used to cover the sensing (catalytic) electrode, and in some cases, it is used to control the molecular weight of the gas reaching the electrode surface.

b) **Electrode**: The electrode material should be a catalytic material that can perform semi-electrolytic reactions over a long period of time. Generally, electrodes are made of precious metals, such as platinum or gold, which react effectively with gas molecules after catalysis.

c) **Electrolyte**: The electrolyte must be able to carry out the electrolysis reaction and effectively transfer the ionic charge to the electrode.

d) **Filter**: Sometimes a scrubber filter is installed in front of the sensor to filter out unwanted gas. The most commonly used filter material is activated carbon.

Application of electrochemical sensors

i. **Humidity sensor -** The sensor used to measure relative humidity is coated with piezoelectric quartz crystal, which is made of small quartz crystal by photolithography and chemical etching technology.

(ii) Detection of toxic gases like nitrogen oxide, hydrogen sulfide and sulfur dioxide with high selectivity and sensitivity

Answer 4b. **Thermometric sensor** quantify the quantity of heat energy or even coldness produced by an item or system, allowing us to “sense” or detect any physical change in that temperature, generating an analog or digital output.

Classification:

The temperature sensor is one of the most frequently used sensors, which is widely used in computers, automobiles, kitchen appliances, air conditioners, and household thermostats. The five common types of temperature sensors include,

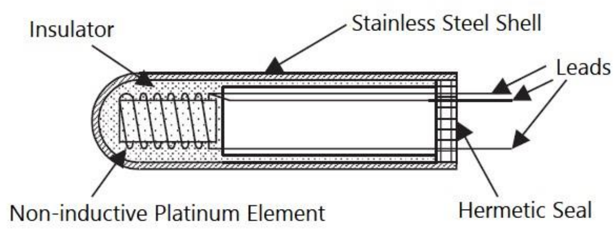
i. Thermocouples,

ii. Thermistors,
iii. RTDs (Resistance Temperature Detectors),
iv. Analog thermometer IC, and
v. Digital thermometer IC.

Working principle:

Different types of temperature sensors have different working principles:

Resistance temperature detectors (RTD) measures the temperature according to the rule that the resistance of the conductor changes with temperature. The temperature-sensing element of resistance thermometers are commonly made of metal wires as platinum and copper, and at low temperatures, carbon, germanium, and rhodium iron are often used for the element. Because they are almost made of platinum, we often call them platinum resistance thermometers.



As the temperature changes, the resistance value of the metal also changes. And for different metals, the resistance value changes differently with the temperature, which can be directly used as the output signal.

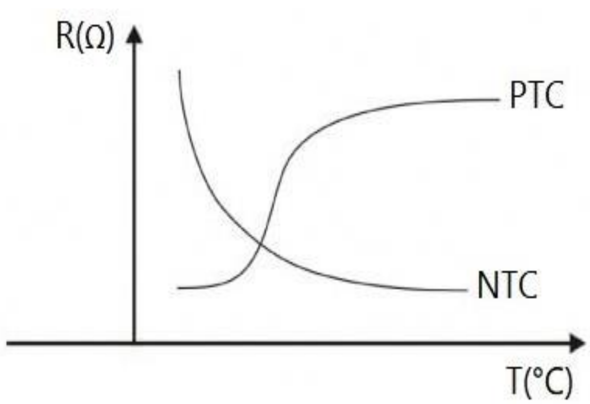
Resistance changes in 2 different ways:

Positive temperature coefficient

- temperature increases & resistance increases
- Temperature decreases & resistance decreases

Negative temperature coefficient

- temperature increases &resistance decreases
- Temperature decreases &resistance increases



Application:

1. **Sensing Application -** The thermal conversion method of temperature sensors is often used to measure physical quantities, such as flow rate, radiation, gas pressure and type, humidity, thermochemical reaction, etc.
2. **Biomedical Domain -** Special temperature sensors are often applied for biomedical applications. These temperature sensors have low power consumption, long-term stability, and high reliability, with an accuracy of less than 0.1℃ between 32℃ C and 44℃
3. **Industrial Application -** Integrated temperature sensors can be applied in automation and microbe thermal detection.
4. **Consumer Products -** Many low-cost integrated temperature sensors and transmitters have been used in consumer products such as washing machines, refrigerators, and air conditioners.

Answer 5a. **Concentration Cells:** In these cells, the two electrodes of same element is in contact with solution of same metal ion (electrolyte) but of different concentration.

Cell representation: Cu / Cu^{2+}(C_1 =0.002 M) // Cu^{2+}(C_2 = x M) / Cu

The Electrode reactions are as follows:

At anode Cu $\rightarrow$ Cu^{2+} (C_1=0.002 M) + $2e^-$

At cathode Cu^{2+} (C_2 = x M) + $2e^-$ $\rightarrow$ Cu

EMF of cell is given by

$$E_{cell} = \frac{2.303\ RT}{nF} \log \frac{C_2}{C_1}$$

$$\mathbf{0.0350 = \frac{2.303 \times 8.314 \times 313}{2 \times 96500} \log \frac{X}{0.002}}$$

X = 0.0267 M

Answer 5b. **<u>Ion Selective electrodes</u>** These electrodes selectively respond to a specific ion in a mixture and potential developed is a function of concentration of that ion in the solution. These electrodes consist of a membrane which is capable of exchanging specific ions with solution with which it is in contact. These are also called as membrane electrodes. Eg. Glass electrode.

Glass Electrode

Construction: The glass electrode consist of glass tube, the bottom of the glass tube is glass bulb made up of very thin glass membrane. The thickness of glass membrane varies from 0.03 mm to 0.1 mm. The membrane is made up of special glass of low melting point and high electrical conductivity. Its

composition is SiO_2 – 72%, Na_2O- 22%, CaO- 6%. It can sense H^+ ions up to a pH of about 9. Glass bulb contains 0.1 N HCl (Assume concentration is C_2). An Ag/AgCl electrode (internal reference electrode) is placed in the solution and connected by a pt wire for electrical contact.

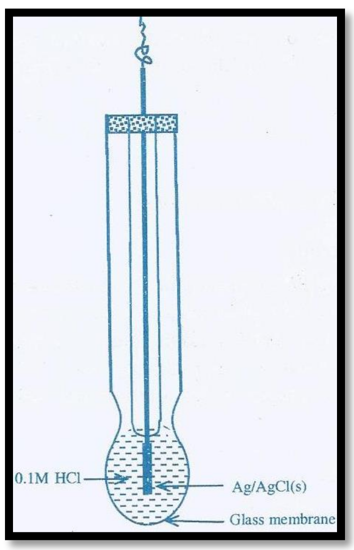


Fig: Glass Electrode

The electrode is represented as, Ag/AgCl (s)/ 0.1N HCl/ Glass

Working of glass electrode: When the glass electrode is dipped into any solution containing H^+ ions, the Na+ ions of the glass membrane are exchanged for H+ ions of the test solution.

$H^+ + Na^+ GI^- \longrightarrow Na^+ + H^+GI^-$

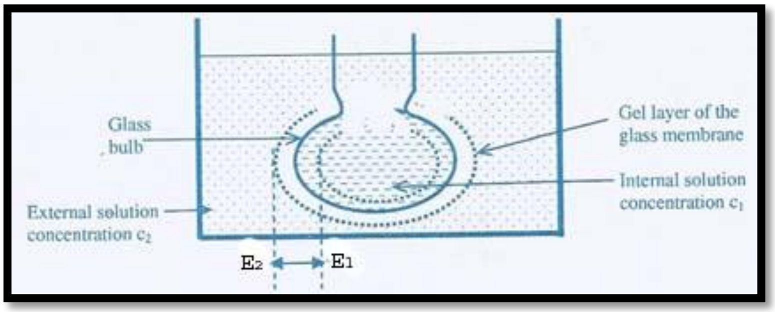


Fig : Boundary Potential ($E_b = E_2$-E_1)

If a thin walled bulb containing an acid is immersed in another solution containing H^+ ions (fig), a potential is developed across the glass membrane. This is called the boundary potential E_b. It is a potential developed across the glass membrane when concentration of the solution inside and outside the glass membrane are different. The E_b is due to the difference in potential (E_2-E_1) developed across the gel layer of the glass membrane between the two liquid.

Mathematically it is represented as,

$$E_b = E_2 - E_1$$

Where, E_2= Potential due to H^+ present in outside solution (Unknown solution)

E_1 = Potential due to H^+ present in inside solution (known solution)

According to Nernst equation

$$E_b = \frac{2.303RT}{nF} \log \frac{C_2}{C_1}$$

$$E_b = \frac{0.0591}{n} \log C_2 - \frac{0.0591}{n} \log C_1 \text{..................(1)}$$

Where, C_2 is the concentration of H^+ ions of the solution into which glass membrane is dipped. The concentration of H^+ ion inside the bulb (C_1) is constant i.e. $C_1 = 0.1$ M.

Thus, $E_b = \frac{0.0591}{n} \log C_2 + K$ or

$$= K + \frac{0.0591}{n} \log C_2$$

Glass electrode selects only H^+ ions ignoring other ions.

Hence $C_2 = H^+$

$E_b = K + 0.0591 \log [H^+]$

Where, $\log [H^+] = -pH$

Thus, $E_b = K - 0.0591pH$ ---------------------**(2)**

The combined glass electrode is dipped into acidic solution, then the potential of the glass electrode is given by….

$E_G = E_b + E_{Ag-AgCl}$ ………………………(3)

From equation 1, theoretically if $C_1 = C_2$, E_b should be 0, however it has been observed practically that even when $C_1 = C_2$, a small potential is developed which is called as asymmetric potential (E_{asym}). Hence equation 3 can be rewritten as

$E_G = E_b + E_{Ag-AgCl} + E_{asym}$ ………………………(4)

Substituting the value of E_b from equation (2) in equation (4)

$E_G = K - 0.0591pH + E_{Ag/AgCl} + E_{assy}$

$E_G = E^o_G - 0.0591pH$ **………………(5)** Where ($E^o_G = K + E_{Ag/AgCl} + E_{assy}$)

The above expression (eq 5) indicate that the potential of glass electrode, E_G varies with the pH of the acidic solution.

Advantages of Glass electrode:

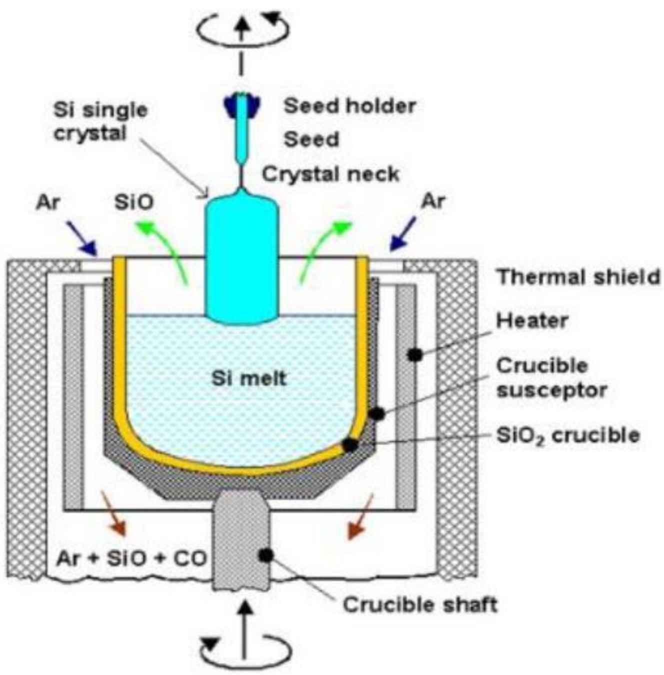
1. It can be used in presence of strong oxidizing /reducing substances and metal ions.
2. It does not get poisoned easily.
3. Equilibrium is easily attained.
4. Portable and compact.

Limitation of glass electrode:

1. It can be used up to pH 13 but becomes sensitive to Na^+ ions above pH 9 resulting in an alkaline error.
2. It does not function satisfactorily in pure alcohol.
3. It has to be handled with care because of glass electrode, and is very fragile.

Answer 6a.

Czochralski process (CZ): The Czochralski process, is a method of crystal growth used to obtain single crystals of semiconductors (e.g. silicon, germanium and gallium arsenide), metals (e.g. palladium, platinum, silver, gold), salts and synthetic gemstones. In this process high-purity polycrystalline silicon is placed in the quartz crucible and melted using a RF coil in an atmosphere of argon. The temperature is maintained at the melting point of the silicon (around 1,412 °C). Dopant impurity atoms such as boron or phosphorus can be added to the molten silicon in precise amounts to dope the silicon, thus changing it into p-type or n-type silicon, with different electronic properties. A rotating puller rod with a seed crystal at the bottom is lowered such that the seed crystal just touches the surface of molten silicon. A slight temperature drop initiates the crystallization of silicon on the seed crystal. The puller rod is pulled out at the rate of 1.5-5 cm/hour and simultaneously rotated at a speed of 100 rpm. As the rod is pulled away from the surface, silicon solidifies and a single crystal of silicon having the same crystal structure as that of the seed crystal is obtained. By precisely controlling the temperature gradients, rate of pulling and speed of rotation, it is possible to extract a large, single-crystal, cylindrical ingot from the melt.

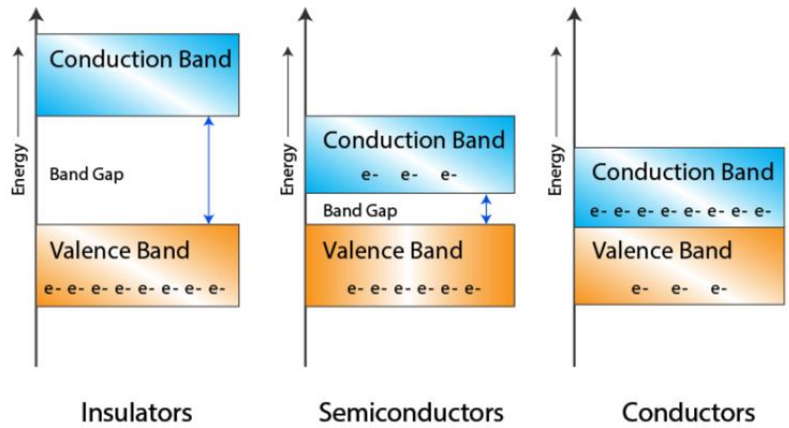


Answer 6b.

Conductors are the materials or substances which allow electricity to flow through them. They conduct electricity because they allow electrons to flow easily inside them from atom to atom. Also, conductors allow the transmission of heat or light from one source to another.

A **semiconductor** is a material which has an electrical conductivity value falling between that of a conductor, such as copper, and an insulator, such as glass. Its resistivity falls as its temperature rises; metals behave in the opposite way. Its conducting properties may be altered in useful ways by introducing impurities ("doping") into the crystal structure

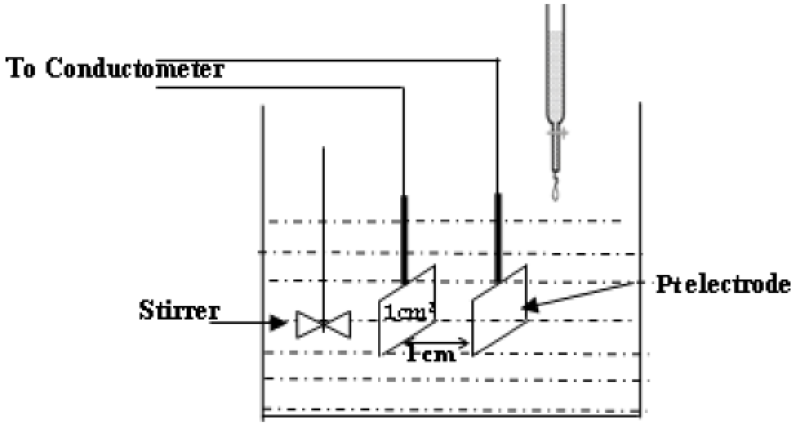
Insulators are the materials or substances which resist or don’t allow the current to flow through them. In general, they are solid in nature. Also, insulators are finding use in a variety of systems. As they do not allow the flow of heat. The property which makes insulators different from conductors is its resistivity.



Band Theory of conduction:
Conductors: According to band theory, a conductor is essentially a substance with its conduction bands and valence bands overlapping, permitting electrons to move freely between the valence band and the conduction band. In conductors, conduction band is only partially filled. This means there are spaces for electrons to move into conduction band and hence thee materials acts as conductors.
Semiconductors: In a semiconductor, the gap between the valence band and conduction band is smaller. The completely occupied valence band and the unoccupied conduction band classify semiconductors. As per band theory semiconductors will operate as insulators at absolute zero. Above this temperature there is sufficient energy available to move some electrons from the valence band into the conduction band and hence material acts as semiconductor. An increase in temperature increases the conductivity of a semiconductor because more electrons will have enough energy to move into the conduction band.
Insulators: An insulator has a large gap between the valence band and the conduction band. The valence band is full and no electrons can move up to the conduction band, hence these material can't conduct.

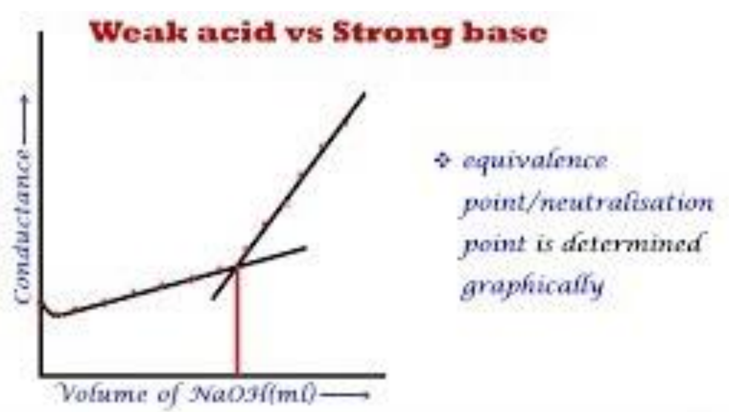
Answer 7a.

Principle: Conductometry is based on Ohm's law which states that the current i (amperes) flowing in a conductor is directly proportional to the applied electromotive force, E (volts), and inversely proportional to the resistance R (ohms) of the conductor. The reciprocal of the resistance is called the conductance (Ease with which electric current flows
through a conductor). Specific conductance of a solution is defined as the conductance of a solution present between two parallel electrodes which have $1cm^2$ area of cross section and which have kept 1 cm apart. The conductance of solution depends on the number and mobility of ions. The substitution of ions with different ionic mobility affects the electrolytic conductivity. Therefore, the equivalence point can be determined by means of conductivity measurement for a neutralization reaction between an acid and a base. Equivalence point is determined graphically by plotting conductance against titer values.
Instrumentation: Conductometer consists of: (1) conductivity cell having two platinum electrodes; and a (ii) conductometer. A simple arrangement of conductometric titration is depicted in figure. The solution to be titrated is taken in the beaker.



Application in the estimation of weak: Pipette out 50ml of sample into a beaker. Immerse the conductivity cell into it. Connect the conductivity cell to a conductivity meter and measure the conductance by adding NaOH from the burette by increment of 1 ml. Plot a graph of conductance against volume of NaOH. Determine the neutralization point from the graph as shown below**.**

Weak acid with a strong base: (CH_3COOH Vs NaOH): In the conductometric titration of a weak acid with a strong base, the conductance of the acid will be initially low due to poor dissociation of acetic acid. On complete neutralization of the acid, further addition of base leads to an increase in the number of more mobile OH^- ions. Hence conductance increases sharply.



Answer 7b. **Graphene Oxide**

- Graphene oxide (GO) is a layered carbon structure with oxygen-containing functional groups (=O, -OH, -O-, -COOH) attached to both sides of the layer as well as the edges of the plane.
- As with any 2D carbon material, GO can also have either single layer or multilayer structure.
- A structure with one layer is graphene oxide; two layers of graphene oxide are referred to as a two-layered GO, GO with five to ten layers is called multi layered GO, and material with eleven or more layers is called graphite oxide.

- In contrary to graphene, GO is hydrophilic, and it is hence relatively simple to prepare a water- or organic solvent-based suspensions.
- Highly oxidized forms of GO are electric insulators with a bandgap of approximately 2.2 eV.
- Simplistically, GO is a monolayer sheet of graphite containing hydroxyl, carboxyl, and epoxy oxygen groups on its basal plane and edges, resulting in a mixture of sp2 and sp3 hybridized carbon atoms.

Properties of Graphene Oxide:

- The properties of graphene can be changed by the functionalization of graphene oxide. The chemically-altered graphene's could possibly be used in several applications.
- Graphene Oxide has a high surface area, and so it can be fit for use as electrode material for batteries, capacitors and solar cells.
- Graphene Oxide is cheaper and easier to manufacture than graphene, and so may enter mass production and use sooner.
- GO can easily be mixed with different polymers and other materials, and enhance properties of composite materials like tensile strength, elasticity, conductivity and more.

Synthesis of Graphene Oxide:

- There are several ways to prepare graphite oxide/graphene oxide. The most common way is to use an oxidizing agent in an acidic environment.
- In this procedure, phosphoric acid is mixed with sulphuric acid in the ratio 1:9 and potassium permanganate and graphite added in the ratio 6:1 in an ice bath.
- The mixture is then heated at 50_oC and stirred for 12 h
- After cooling down, the mixture is poured onto ice
- Finally, 30% H_2O_2 is added in order to remove the excess of potassium permanganate.
- Phosphoric acid works as a dispersive and etching agent, as well as a stabilizer of the oxidation process, which makes the synthesis of GO safe.
- This route produces a higher yield of GO with a higher level of oxidation and a more regular structure.

Applications of Graphene Oxide:

- Air pollution caused by the industrial release of harmful gases such as CO_2, CO, NO_2, and NH_3.
- GO can be employed in catalysis for converting polluting gases during industrial processing.
- The approach of GO application in this area can be divided into two paths: pollutant adsorption and conversion.
- The functional groups of few-layered GO composites exhibit unique adsorption behaviour towards different gases like acetone, formaldehyde, H_2S, SO_2 , and NO_x can be adsorbed by GO-based composites.
- GO exhibits high adsorption ability towards Cd(II), Co(II), Au(III), Pd(II), Ga(III), and Pt(IV).
- Adsorption ability mainly depends on the synthesizing method. Multilayered graphene oxide nanosheets show a very high affinity towards Pb(II) ions, with a sorption capacity of about 842 mg g^{-1} at 293 K.
- Small-molecule drug delivery seems to be another promising medical application of GO. Small molecules of drugs can be attached to a GO surface using pH-sensitive linkers.