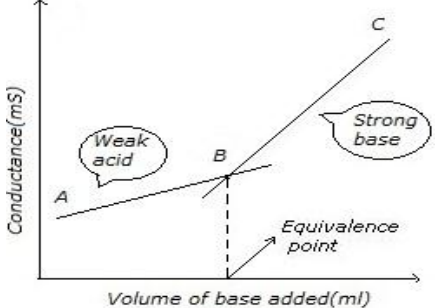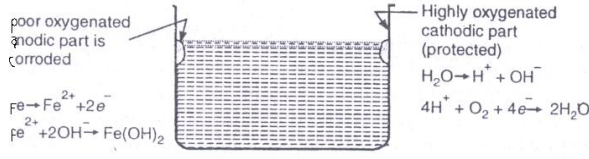# FACULTY OF ENGINEERING OSMANIA UNIVERSITY

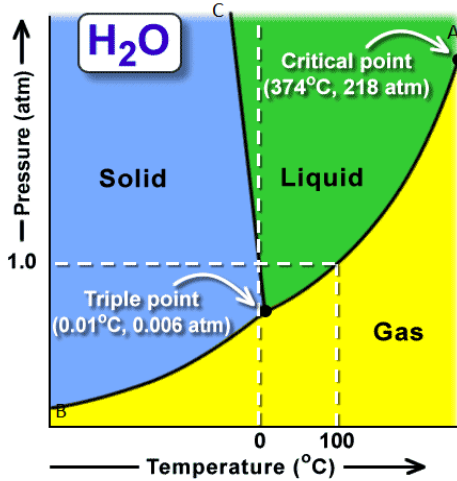B.E. I – Year (New) (Main) Examination, June / July 2015

Subject: Engineering Chemistry (Code No. 9358 / N) Time: 3 Hours Max. Marks: 75
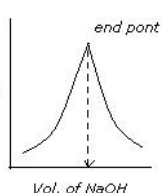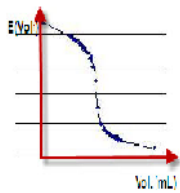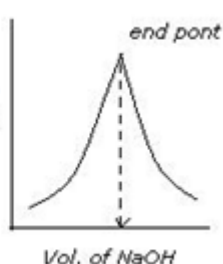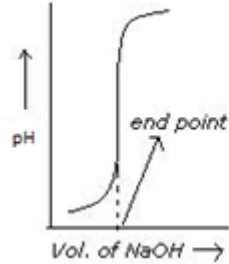
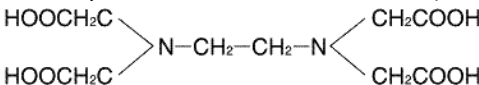| Q. N	Key Points	Marks
	PART – A	
1.	**Represent Calomel electrode and write the electrodic reaction for reduction process and mention the S.R.P. value of the electrode.**	
Ans.	Cell Representation of SCE: Sat. KCl l $Hg_2Cl_{2(s)}$ l Hg, Pt Electrodic reaction: $Hg_2Cl_2 + 2e^- \rightarrow 2Hg + 2Cl^-$ and S.R.P. value = 0.242 V	1 1 1
2	**Draw the conductometric titration plot of weak acid against strong base and explain the graph.**	
Ans.	Acetic acid is a weak electrolyte has low conductivity, as represented by A. As NaOH is added, the poorly conducting acid is converted into highly ionized salt, CH_3COONa and consequently the conductivity goes up along AB, the deciding factor on this curve is presence of Na^+ ions. When the acid is neutralized, further addition of alkali causes a sharp rise in conductance along BC due to presence of highly mobile OH^- ions. The intersection of AB and BC represents the equivalence point. $CH_3COOH + NaOH \longrightarrow CH_3COO^-Na^+ + H_2O$	1 1
3	**What is waterline corrosion? Explain.**	
Ans.	The water line corrosion takes place due to the formation of differential oxygen concentration cell. The part of the metal below the water line exposed only to the dissolved oxygen while the part above the water is exposed to higher concentration of the atmosphere of the atmosphere. Thus, part of the metal below the water acts as anode and undergoes corrosion and the part above the water line is free from corrosion.	A distinct brown line is formed just blow the water line due to the deposition of rust. At anode: Fe --------$\rightarrow$ Fe^{2+} + $2e^-$ (Oxidation) At cathode: ½ O_2 + H_2O + $2e^-$ -------$\rightarrow$ 2 OH^- **[Fig: Water storage steel tank]**	1 2
4	**Name three substances used for sterilization of water.**	
Ans.	Ozone, Chlorine, Bleaching powder	2
5	**Define the term "functionality" of monomers. Explain its significance with a suitable example.**	
Ans.	For a substance to act as a monomer, it must have at least two reactive sites or bonding sites. No of reactive or bonding sites in a monomer is called functionality. If a monomer is bi functional – they form linear or straight chain molecules; whereas a tri functional has 3 reactive sites then it forms a branched chain polymer with 3-diemensional network.	1 1
6	**Explain the types of composite materials.**	
Ans.	A composite is a combined material formed by the assembly of two or more components, such as fillers or reinforcing agents and a compatible matrix binder in order to obtain specific characteristic properties. Two or more distinct components which combine to form a new class of material suitable for structural application are referred as composite materials. **W.r.t. to the matrix constituent.** Organic matrix composites (OMCs), metal matrix composites (MMCs) and ceramic matrix composites (CMCs), Polymer matrix composites (PMCs) and Carbon matrix composites (CMCs). **W.r.t. the reinforcement form**. These are composed of fibers embedded in the matrix material. Fiber reinforced composites, Laminar composites and Particulate composites. Laminar composites are composed of layers of materials held together by matrix. Eg. Sandwich structures. Particulate composites are composed of particles distributed or embedded in a matrix body. Eg. Concrete and wood particle boards.	1+1+1

	FRP are composed of fibers and a polymer matrix. Fibers are the reinforcement and the main source of strength, while the polymer marix "glues" all the fibers together in shape and transfers stresses between the reinforcing fibers. Three types of Composite materials with example. (Particulate, Layer and Fiber reinforced composite materials)	
7	**Define octane number. How will you improve the anti-knocking value of fuel?**	
Ans.	The %age by volume of isooctane in the isooctane – heptane mixture that matches the knocking characteristics of the fuel being tested is called the Octane number. The knocking could be prevented by adding TEL, Benzene, MTBE etc.	2 1
8	**Classify rocket fuels.**	
Ans.	Solid (Homo / when solid propellants are thoroughly mixed in a colloidal state and hetero / when an oxidizing agent is dispersed in a fuel mass, the solid propellant is called heterogeneous) and Liquid (mono and bi) Propellants.	1 + 1
9	**Define phase and component.**	
Ans.	A phase is a homogeneous, physically distinct and mechanically separable part of a heterogeneous system which can be separated by definite surface boundaries. Defined as the minimum number of chemically independent species which are required to express the composition of all the phases present in the system.	1 + 1
10	**Classify lubricants and give one example each.**	
Ans.	Solid lubricants (Graphite) Liquid Lub. (Animal/veg/mineral oils) Semi soild (Greese)	1 1 1

PART – B

11 (a)	**For the cell reaction Zn(s)+Fe2+⇌Zn2++Fe(s). Calculate the reactive concentration of Zn2+ and Fe2+ at which the overall cell E.M.F. becomes zero. $E^o_{Fe^{+2}/Fe}$ = -0.440 V E^o, $Zn\,2+/Zn$ = -0.760 V.**	
Ans.	E^o_{Cell} = 0.32 V Nernst equation, formula and substitution Antilog of 10.84 Relative ration = 6.9 x 10^{10}	2 2 1 1
11 (b)	**Explain hydrogen – oxygen fuel cell.**	
Ans.	It is one of the simplest and most successful fuel cell. It consists essentially of an electrolytic solution such as 25% KOH solution, and two inert porous electrodes. Hydrogen and oxygen gases are bubbled through the anode and cathode compartment respectively, where the following reactions take place: Anode: $2H_{2(g)} + 4 OH^-_{(aq)} \rightarrow 4 H_2O_{(l)} + 4$ e- Cathode: $O_{2(g)} + 2 H_2O_{(l)} + 4$ e- $\rightarrow 4 OH^-_{(aq)}$ --- Net reaction: $2H_{2(g)} + O_{2(g)} \rightarrow 2 H_2O_{(l)}$ The standard emf of the cell $E^0 = E^0_{ox} + E^0_{red}$ = 0.83 V + 1.23 V In actual practice, the emf of cell is 0.8 to 1.0 V. It may be noted that the only product discharged by the cell is water. Usually, a large number of these cells are stacked together in series to make a battery, called *fuel cell battery or fuel battery.*	It may be pointed have that they must be excellent catalysts for the reactions that take place on their surfaces. When hydrogen is used as the fuel, the electrodes are made of either graphite impregnated with finely divided platinum, or a 75/25 alloy of palladium and silver, or nickel. Electrolytes used for most often are aqueous KOH or H_2SO_4 or ion-exchange resin saturated with water. For low-temperature operating fuel battery potassium thiocyanate dissolved in liquid ammonia is employed. Cell potential / Cell Potential (Theoretical) = 1.23V (Practically))0.8 to 1V	1 2 1
12 (a)	**Define metallic corrosion. Explain electrochemical theory of corrosion.**	
Ans.	This type of corrosion can be observed when a metal is in contact with conducting liquid. When two dissimilar metals are dipped partially in a solution. This corrosion occurs due to the existence of separate 'anodic' and 'cathodic' areas. Impact of corrosive environment on a portion of	At cathodic area, reduction reaction takes place. Usually, cathode reactions do not affect the cathode, since most metals cannot be further reduced. So, at cathodic part, dissolved constituents in the conducting medium accept the electrons to form some ions like OH⁻, O²⁻. The metallic ion formed at anodic part and non-metallic ion formed at cathode part diffuse towards each	2 4

	metal, changes its electrode potential compared to its original value of the electrode potential of the metal. This creates a potential difference within the metal system. The area of lower reduction potential created in the metal is known as the '**anodic area'** and that with higher reduction potential value is called '**cathodic area'**.
	
	      The current flows from the anodic area to the cathodic area through the conducting solution. A galvanic cell is created in the metal.
	
	      At anodic area, oxidation reaction takes place, so metal is destroyed by either dissolving or assuming combined state. Hence, corrosion always occurs at anodic area.
	      At anodic area: $M \rightarrow M^{n+} + n e^-$
	            (Oxidation)
	$M^{n+} \rightarrow$ dissolves in solution or forms compound such as oxide.
		other through conducting medium and forms a corrosion product somewhere between anode and cathode. The electrons set free at the anode flow through the metal and are finally consumed in the cathodic reaction.
		Thus, we may sum up that electrochemical corrosion involves:
		i) The formation of anodic and cathodic areas or parts in contact with each other,
		ii) Presence of a conducting medium,
		iii) Corrosion of anodic areas only,
		iv)Formation of corrosion product somewhere between anodic and cathodic areas.
		The cathodic reaction consumes electrons with either by i) evolution of hydrogen, or ii) absorption of oxygen depending on the nature of the corrosive environment	

12 (b)	**What are the characteristics of a paint? Name the various constituents of paints.**		
Ans.	Characteristics of paints – 4 Points **Constituents of paints:-** pigment is a solid substance which is an essential constituent of paint it provides i) Capacity to paints ii) Strength to paint iii) desired color to paint iv) Aesthetical appeal to the paint film. (v) Protection to the paint film by reflecting harmful ultra violet light (vi) Resistance to paint film against abrasion/wear (vii) impermeability of paint film to moisture (viii) increases the weather resistance of the film. **Vehicle or Drying Oil**: is a filon forming constituent of the paint. These are glyceryl esters of high molecular-weight fatty acids generally present in animal and vegetable oils. The most widely used drying oils are linseed oil, soya bean oil and castor oil. Drying oil supplies i) Main Film-forming constituent ii)Vehicle or medium iii)Toughness iv)adhesion V)Durability Vi) and water proof ness. **Thinners**: i) Reduce the viscosity of the paint to suitable consistency, so that it can easily be handled and applied. ii)Dissolves the vehicle and the additions increases the penetration power of the vehicle iii) helps the drying of the paint film, as they evaporate. Common thinners are turpentine , benzene, dipentene, naptha, kerosene etc… **Driers:** are oxygen carrier catalysts, they accelerate the drying of the oil film through oxidation, polymerization and condensation. Thus they improve the drying quality of the oil film. The most effective driers are resonates, lenoleates, tungstates of Co,Mn,Pb and Zinc. **Extenders or fillers**: They are added in limited quantities to the oil paints for adjusting the working quantities of the paint they help to present the setting of heavier pigments. i) They also increases the mechanical strength of the paint film. ii) They reduce the cost of the paint eg.s are aluminium silicate, barium carbonate, barium sulphate. **Plasticizers**: some times plasticizes are added to the paint. They do not evaporate like thinners and they permanently remain in paints. i)They improve flexibility and elasticity of the paint film. ii) They minimize its cracking Eg. High molecular weight esters like triphenyl phosphate tributyl phosphate, tricresyl phosphate etc. **Anti Skinning agents**: They are sometimes added to paints to prevent gelling and skinning of the paint film.		2 2
13 (a)	**Differentiate between homopolymer and co-polymer.**		

Ans.	*Homopolymer*: Polymer made up of only one type of monomer.
	      (-M-M-M-M-)n Ex: Polyethylene.
	Co-polymer: Polymer formed by the reaction between different monomers.
	      $(M_1-M_2-M_1-M_2-)n$ Ex: Buna-S, Thiokol etc.
			4

13 (b)	**What are conducting polymers? Discuss the applications of conducting polymers.**		
Ans.	Conducting polymers have backbones of continuous sp^2 hybridized carbon centers. One valence electron on each center resides in a p_z orbital, which is orthogonal to the other three sigma-bonds. The electrons in these delocalized orbitals have high mobility. Applications: 1. Conducting polymers are useful in discharging large quantities of static electricity in computer industries and in chemical industries. This can be accomplished by coating the conducting polymer over an insulating surface. Hence conducting polymers are used as antistatics. 2.Conducting polymers can absorb harmful electromagnetic radiation. So these can be used to coat on the cases of computer monitors and cell phones. 3. Printed circuit boards are used in electrical and electronic instruments. They contain copper coated		2 2

epoxy resins which are expensive and have less adhesive nature. But polymer sheets coated with conducting polymers are inexpensive and have better adhesive properties.

4. These are useful in the preparation of artificial nerves i.e., biocompatible conductive polymers can be used for transmitting electrical signals in the body.

5. Artificial intelligent materials: These are also called as smart materials. The interesting aspects of these materials is that they can remember configuration and can confirm when exactly same stimulus is given. This property can be utilized in generating pass words where high security is required. .

6. As already explained that the conducting polymers can undergo oxidation and reduction depending upon the reagent with which they react. This property can be utilized in detecting the gases. For example, the resistance of poly pyrrole increases on contact with NH_3 (reducing gas) while the resistance decreases in presence of NO_2 (oxidizing gas).

7. Polymer rechargeable batteries: Repeated oxidation and reduction of polymeric back bone constitutes the principle of polymer rechargeable batteries. For example, in poly pyrrole lithium cell is useful rechargeable battery compared to conventional Ni-Cd cell. Because the polymer rechargeable cells do contain heavy metals. So, these are environmentally safe and non toxic.

8 .For making ion exchange membranes: Semi permeable membranes can be manufactured using conducting polymers which selectively permit ions or gases. This property can be exploited in ion exchangers and controlled release of medicines.

9 Biosensors : It is one of the interesting application of the conducting polymer. We know that glucose can be oxidized in presence of oxygen produce H_2O_2. So produced H_2O_2 can oxidize iodide ions to triiodide ions. The triiodide can enhance the conductivity of polyacetylene. So by measuring the conductivity, concentration of triiodide hence peroxide and finally that of glucose can be found.

10. These are useful as corrosion inhibitors.

11. These can applied in Flat Panel Displays (less than 2 mm thick) which are thinner than liquid crystals displays or plasma displays

12. These are also useful as Flexible Display Devices for mobile phones, Personal Digital Assistants and watches etc. Combining different conducting polymers with different emitting colors multicolor displays can be manufactured.

14 (a)	**What are chemical fuels? How are they classified? Give suitable examples for each class.**	
Ans.	A **fuel** can be defined as a combustible substance containing carbon as the major constituent which gives large amount of heat on burning, which can be used for domestic and industrial purposes. **Fuel + O2 → Products + Heat.** 1. FOSSIL FUELS: Solid fuels (COAL), Liquid fuels (OIL), Gaseous fuels (NATURAL GAS) 2. NUCLEAR FUELS 3. RENEWABLE FUELS (BIOMASS) 4. WASTE FUELS (MUNICIPAL WASTES)	1 3
14 (b)	**A gaseous fuel has the following composition by volume: H2 = 25%, methane = 30%, ethane = 11%, ethylene = 4.5%, butane = 2.5%, CO = 6.0%, CO2 = 8%, O2 = 2% and N2 = 12%. Calculate the air fuel ratio and volumetric analysis of dry products of combustion using 40% excess air.**	
Ans.	Air – fuel ratio = 9.45 : 1 Dry Products: % CO_2 = 9.45, % N_2 = 84.3 Volume of O_2 = 1.4.17, Volume of air = 6.25, 40% of excess = 9.45	5 + 1 Or 4 + 2
15 (a)	**Write the principles of Green Chemistry.**	
Ans.	1. **Prevention** :It is better to prevent waste than to treat or clean up waste after it has been created. 2. **Atom Economy**: Synthetic methods should be designed to maximize the incorporation of all materials used in the process into the final product. 3. **Less Hazardous Chemical Syntheses**: Wherever practicable, synthetic methods should be designed to use and generate substances that possess little or no toxicity to	7. **Use of Renewable Feedstocks**: A raw material or feedstock 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 processes) should be minimized or avoided if possible, because such steps require additional reagents and can generate waste. 9. **Catalysis**: Catalytic reagents (as selective as possible) are superior to stoichiometric reagents. 10. **Design for Degradation**: Chemical products should	5

	human health and the environment. **4. Designing Safer Chemicals**: Chemical products should be designed to affect their desired function while minimizing their toxicity. **5. Safer Solvents and Auxiliaries**: The use of auxiliary substances (e.g., solvents, separation agents, etc.) should be made unnecessary wherever possible and innocuous when used. **6. Design for Energy Efficiency**: Energy requirements of chemical processes should be recognized for their environmental and economic impacts and should be minimized. If possible, synthetic methods should be conducted at ambient temperature and pressure.	be designed so that at the end of their function they break down into innocuous degradation products and do not persist in the environment. **11. Real-time analysis for Pollution Prevention**: Analytical methodologies need to be further developed to allow for real-time, in-process monitoring and control prior to the formation of hazardous substances. **12. Inherently Safer Chemistry for Accident Prevention**: Substances and the form of a substance used in a chemical process should be chosen to minimize the potential for chemical accidents, including releases, explosions, and fires.	

15 (b)	**Draw a neat diagram of water system and label the parts. Calculate the degree of freedom at triple point.**	
Ans.	The phase diagram of Water system consists of i) Three stable curves OA, OB and OC. ii) The area AOB, AOC and COB. iii) Triple point O, represents the equilibrium between the 3 phases. iv) One meta stable curve OA` **iii) Triple point:** the point O, where the three curves meet is called triple point. At this point, all the three ice, water and vapour phases are in equilibrium. This point is nonvariant. i.e. degree of freedom is zero, $F = C-P+2 = 1-3+2 = 0$. If any of the variable is changed then the number of phases decrease. This point corresponds to 0.0078^0C and 4.58 mm Hg. **iv) Curve OA`** is a meta stable curve which is an extension of AO. This represents that water can be super cooled without appearance of ice. Along this curve water coexist with vapour. This is a meta stable equilibrium as slight disturbance brings to the stable curve OB.		3 2

16 (a)	**Derive Nernst equation.**	
Ans.	Definition: In Electrochemistry, Nernst equation can be used to determine the Potential of a Half-cell in an Electrochemical Cell or to determine Total Voltage (emf) of a full cell. Gibbs' Free Energy and Cell potential Let's now relate the electrochemistry ideas we've explored with the thermodynamic parameter called Gibbs' Free Energy. From Thermodynamics, for a process carried out at constant Temperature and Pressure conditions we have, $\Delta G = W_{max}$ --------------$\rightarrow$ (1) In a Galvanic Cell, all the Chemical Energy is converted into Electrical Energy. Hence the maximum work becomes equal to the Electrical work done by the cell. Therefore, $\Delta max = W_{Electrical}$ --------------$\rightarrow$ (2) If the Cell reaction involves transfer of 'n' moles of e-, this corresponds to the flow of 'nF' Faradays of electricity. The Electrical work is given by the product of emf (volt) and the Total charge (nF Coloumbs). i.e $\quad W_{Electrical} = n F E_{CELL}$ --------------$\rightarrow$ (3) Since electrical energy produced is equal to the decrease in the Free Energy of the cell reaction, We have; $- \Delta G = n F E_{CELL}$ --------------$\rightarrow$ (4) Similarly for Standard state of condition we have, $- \Delta G_0 = nFE^0_{CELL}$ --------------$\rightarrow$ (5) Consider a Redox reaction of the type occurring in the Cell; $a A + b B \rightarrow \quad c C + d D$ The Gibbs free energy change is given by the equation; $\Delta G = \Delta G° + R T \ln Q$ --------------$\rightarrow$ (6) Where, $\ln Q = [P] / [R]$	4

	Substitute Equation (4 & 5) in Equation (6), we have; - n F E_{CELL} = - n F E° + R T ln Q E_{CELL} = E_0 – RT / nF ln Q E_{CELL} = E_0 – RT / nF 2.303 log Q --------------→ (7) We have R = 8.314 J/K.mol T = 298K (the absolute temperature of the reaction), F = 96.500 Coulombs Therefore, at 250 C (298K), E_{CELL} = E° - (0.0591 / n) log Q --------------→ (8) **The Equation is known as the Nernst equation.**	

16 (b)	**Differentiate between potentiometric titrations and pH metric titrations by taking a suitable example like HCl Vs NaOH.**	
Ans.	*Acid-Base titration:* The acid solution whose strength has to be determined is taken in a beaker and the hydrogen electrode and calomel electrode were dipped in the solution. The electrodes were connected to the potentiometer and the e.m.f. is measured. Reference Electrode: SCE (SRP = 0.242 V) [Anode] Indicator Electrode: Quinhydrone Electrode [Cathode] Cell Notation: (-) Pt I Hg, Hg_2Cl_2 I KCl (sat) II H^+ Test Sol. I Q, QH_2 I Pt (+) Cell Reactions: @ Anode: $2Hg + 2Cl^- \rightarrow Hg_2Cl_2 + 2e^-$ @ Cathode: $Q + 2H^+ + 2e^- \rightarrow QH_2$ Therefore $E_{Cell} = E_{Cathode} – E_{Anode}$ = [0.0990 – 0.0591 pH] – 0.242 i.e. E_{Cell} is a function of pH. During titration, as base is added to the acid, the H^+ ion concentration in the half cell containing Quinhydrone will decrease. Correspondingly, there will be a decrease in the E_{QE} and E_{Cell} values also. E_{Cell} values are noted, graph is plotted, where equivalence point is located and concentration of test solution is calculated. The steepest portion of the curve indicates the equivalent point of the titration. Instead ΔE/ΔV is plotted against the volume of the base.	Reference Electrode: SCE (SRP = 0.242 V) [Anode] Indicator Electrode: Glass Electrode [Cathode] Cell Notation: **(-) Pt I Hg, Hg_2Cl_2 I KCl (sat) I Test sol of Unknown conc I Glass Membrane I 0.1N H^+ Sol. I AgCl, Ag I Pt (+)** Cell Reactions: @ Anode: $2Hg + 2Cl^- \rightarrow Hg_2Cl_2 + 2e^-$ @ Cathode: $2AgCl + 2e^- \rightarrow 2Ag + 2Cl^-$ Therefore $E_{Cell} = E_{Glass} – E_{SCE}$ $E_{Cell} = E^0_{Glass} – 0.0591$ pH – 0.242 OR pH = $(E^0_{Glass} – E_{Cell} – 0.242) / 0.0591$ In the titration of SA Vs SB, as the base is added to the acid, the OH^- ions of the base react with the H^+ ions of the acid forming water. Consequently, the H^+ concentration in the acid will decrease, i.e. the pH of the acid will progressively increase. Initially the change in the pH will be gradual, however near the neutralization point a sharp increase in the pH from about 4 to 10 within 0.2 ml range of the base added, around the end point. From the plot of the pH against the volume (V) of the base added, the end point of the titration will be obtained. Plot of ΔpH / ΔV Vs Vml in the vicinity of the equivalence point will give a curve whose peak indicates a sharp end point. 	6

17 (a)	**How do you determine the permanent hardness of water by EDTA method? Explain.**	
Ans.	It is a complexometric method. Ethylene diamine tetra acetic aced (EDTA): In order to determine the equivalence point, indicator erochrome black-T or EBT (an alcoholic solution of blue dye) is employed. However, this indicator is effective at a pH of about 10. When EBT is added to hard water buffered to a pH of about 10 by employing NH_4OH+NH_4Cl buffer, a wine-red unstable complex is formed.	5

pH=10

$$M^{2+} + EBT \text{---------}\rightarrow [M\text{-}EBT] \text{ complex}$$

So initially a wine-red colored complex is obtained. During the course of titration against EDTA solution, EDTA combines with M^{2+} (Ca^{2+} or Mg^{2+}) ions form stable complex M-EDTA and releasing free EBT, and wine-red color changes to blue color (due to EBT).

$$[M\text{-}EBT] \text{ complex} + EDTA \text{--------}\rightarrow [M\text{-}EDTA] \text{ complex} + EBT$$
(_Wine-red_**)**   (_Blue_)

Thus, change of wine-red color to distinct blue marks the end-point of titration.

Part-I: Standardization of EDTA Solution:

       1gm of $CaCO_3$ dissolved in HCl and diluted to 1000 ml with distilled water.

1gm of $CaCO_3$	=	1000ml of SHW
1000mg of $CaCO_3$=		1000ml of SHW

Therefore,

1ml of SHW	=	1mg of $CaCO_3$

Let V_1 ml of EDTA consumed for 20 ml of SHW. Then

V_1 ml of EDTA	=	20ml of SHW
	=	20mg of $CaCO_3$

Therefore,

1 ml of EDTA	=	?
	=	$(20 / V_1)$ mg of $CaCO_3$ ---------- (1)

Part-II: Estimation of Total Hardness:

Let V_2 ml of EDTA consumed for 20 ml of water sample. Then

20ml of Water Sample	=	V_2 ml of EDTA
	=	$[V_2 * (20 / V_1)]$ mg of $CaCO_3$
1 ml of Water Sample	=	?
	=	$[V_2*(20 / V_1) *1/20]$ mg of $CaCO_3$
	=	**(V_2 / V_1) mg of $CaCO_3$**

And,

1000ml of water sample = **$(V_2/V_1)*1000$** mg of $CaCO_3$ (or) ppm.

Part-III: Estimation of Permanent Hardness:

Let V_3 ml of EDTA consumed for 20 ml of Boiled water sample. Then

20ml of Boiled Water Sample	=	V_3 ml of EDTA
	=	$[V_3*(20/V_1)]$ mg of $CaCO_3$
1 ml of Water Sample	=	?
		$=[V_3*(20/V_1)*1/20]$ mg of $CaCO_3$
		$=(V_3 / V_1)$ mg of $CaCO_3$

And,

1000ml of water sample **$=(V_3/V_1)*1000$** mg of $CaCO_3$ (or) ppm.

Part-IV: Estimation of Temporary Hardness

Temporary hardness = [Total hardness – Permanent hardness]

$$=\frac{1000\,(V2 - V3)}{V1}\ ppm$$

17 (b)	**Explain the mechanism of extreme-pressure (or Temperature) lubrication.**		
Ans.	When the moving / sliding surfaces are under very high pressure and speed, a high local temperature is realized and under such conditions, liquid lubricants may fail to stick and may decompose or vaporize. Hence for these extreme pressure conditions, special additives are added to mineral oil. These are called extreme pressure additives. These additives form more durable films on metal surfaces, capable of withstanding very high loads and high temperatures. Important additives are organic compouds having active groups such as chlorine, sulphur or phosphorus. These compounds react with metallic surfaces at the high working temperatures to form metallic chlorides, sulphides or phophides, respectively. These metallic compounds possess high melting points i.e from 650° to 1100^0 C and serve as good lubricants under extreme pressure and temperature conditions.	5	