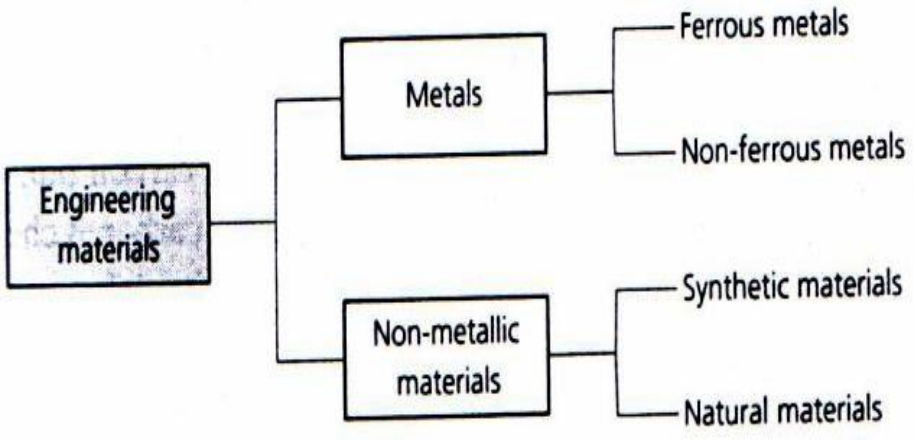
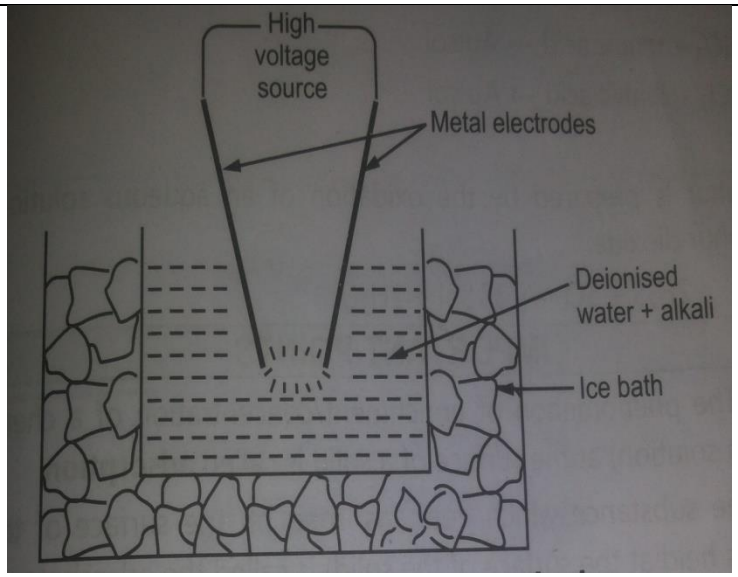
Important Instructions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more Importance (Not applicable for subject English and Communication Skills).
4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.
7) For programming language papers, credit may be given to any other program based on equivalent concept.

Q No.	Answer	Marking scheme
1	**Attempt any six**	**12**
1.a-i	**Isobaric process:** An isobaric process is a thermodynamic process in which the pressure stays constant: $\Delta P = 0$. **Isothermal process:** An isothermal process is a change of a system, in which the temperature remains constant: $\Delta T = 0$. This typically occurs when a system is in contact with an outside thermal reservoir (heat bath), and the change occurs slowly enough to allow the system to continually adjust to the temperature of the reservoir through heat exchange.	1 1
1.a-ii	**Adsorbate-**The substance that gets adsorbed is called the Adsorbate. It can be a gas or vapor or a solute in a solution. For e.g. ammonia, hydrogen. **Adsorbent**-The substance on whose surface adsorption takes place is called the adsorbent. For e.g. charcoal	1 1
1.a-iii	**Corrosion** is defined as the gradual deterioration or destruction of a metal by chemical or electrochemical reactions with its environment.	2
1.a-iv	**Phase Rule** It states that the number of degrees of freedom of in a physical system at equilibrium is equal to the number of components in the system minus the number of phases plus the constants 2. Mathematically, it is stated as follows: $F = C - P + 2$ Where - C is the number of components,	2

	P is the number of phases in thermodynamic equilibrium with each other and F is the number of degrees of freedom or variance of the system.	
1.a-v	**Extensive property** An extensive property is a property that changes when the size of the sample changes. Examples are mass, volume, length, and total charge **Intensive property** An intensive property doesn't change when you take away some of the sample. Examples are temperature, color, hardness, melting point, boiling point, pressure, molecular weight, and density. Because intensive properties are sometimes characteristic of a particular material, they can be helpful as clues in identifying unknown substances.	1 1
1.a-vi	**Classification of engineering materials:** 	2
1a-vii	**Passivity of metals**: **I**n physical chemistry and engineering, refers to a material becoming "passive," that is, less affected or corroded by the environment of future use. Passivation involves creation of an outer layer of shield material that is applied as a microcoating, created by chemical reaction with the base material, or allowed to build from spontaneous oxidation in the air. As a technique, passivation is the use of a light coat of a protective material, such as metal oxide, to create a shell	2

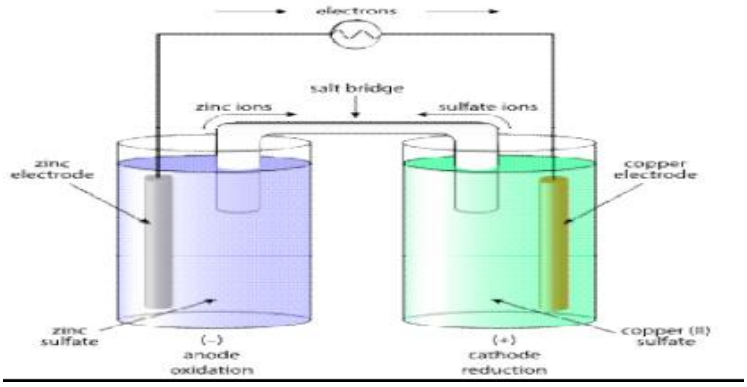
	against corrosion.	
1.b	**Answer any two**	**8**
1.b-i	**Dispersion method:** i) Mechanical dispersion ii) Electrical dispersion iii) Peptization **Electrical dispersion (Bredig's arc method)** This methods is used to prepare hydrosols of metals such as silver, gold & platinum. This method uses two electrodes that are made of the metal of which sol is to be prepared. These electrodes are immersed in deionized water containing a trace of alkali contained in a container. Water is cooled by immersing the container in an ice or water bath. An arc is struck between the two electrodes held close together. The large amount of heat generated by the spark across the electrodes vaporizes some of the metal & the vapors condense immediately in water to yield colloidal solution. The small amount of alkali added to the water helps to stabilize the sol. This method is used for preparing silver & gold sols.	4 marks for any one

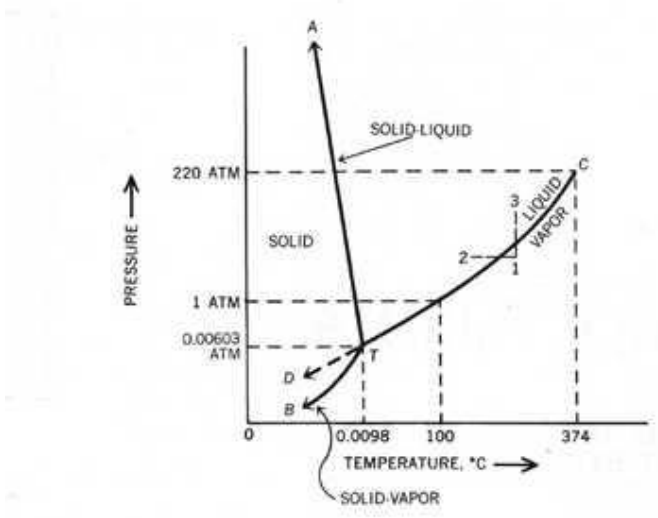
	 **Mechanical dispersion** using colloidal mill The solid along with the liquid is fed into a colloidal mill. The colloidal mill consists of two steel plates nearly touching each other and rotating in opposite directions with high speed. The solid particles are ground down to colloidal size and then dispersed in the liquid. Colloidal graphite and printing inks are made by this method. ***Any other method explained by the student should be given marks***	
1.b-ii	**Mechanism of dry corrosion :** Types of dry corrosion: (i) corrosion by oxygen (ii) corrosion due to other gases **(i) corrosion by oxygen:** Corrosion by oxygen is the corrosion of a metal due to chemical attack of oxygen in dry environment at low or high temp. .it results in the formation of metal oxide layer on the metal surface according to the following reaction : $2M + n\ O2 \rightarrow 2MOn$	4

	Initially a thin layer of oxide film is formed and it gradually grows with time. The nature of metal oxide film/layer formed decides the prevention or continuation of corrosion. The oxide film produced based on its nature can be classified as: (i)stable oxide film : it acts as a barrier between metal and oxygen and thus prevents further corrosion. it may be porous or non-porous in nature (ii) unstable oxide film : when the oxide film is umstable , it decomposes back to the metal and oxygen. Hence oxidation corrosion is not possible in case of nobel metals such as Ag , Au as they are protected by this manner. (ii)volatile oxide film : when oxide film formed is volatile, it volatalises as soon as it is formed and metal surface is exposed to further corrosion. Hence it leads to continuous and excessive corrosion. OR Corrosion by other gases	
1.b-iii	i)**Rubber Lining:** Rubber Lining is an application method used to protect multiple types of systems by lining corrosion and abrasion-resistant rubber upon the surface or inside of pipes and tanks. Lining is done by hand by our experienced staff for a durable finished product, so having application accuracy by qualified liners and crews are a must. The equipments to be lined, working conditions and environment are different for each customer. Therefore, selecting the most suitable material is a crucial procedure that we provide to cater to their specification Applicatiion: Steeland non ferrous industry Organic chemical industry Fertilizer industry Pollution control equipment	1

	ii)Glass Lining: Glass resistance is excellent resistance to all acids .it is subjected to alkali attack. Glass is also damage by thermal shock. Methods foe glass lining are: Wet spray process: The metal surface of a vessel on which glass lining is to be done is cleaned. A suspension called slip consisting of enamel powder and emulsifying agent I sprayed like a paint on metal surface, then the coat is drayed and then the vessel is transfer to a furnace and fired at temp that result in fusion of partials. Hot dust method: It is generally applicable to cast iron components' he process is similar to wet spray only after coating dry powder cover coat enamels is dusted. Application: Reactor Acid storage tank Pipeline Column **iii)Lead Lining:** Lead lining is the process of applying lead to sheet metal, plastics or castings. Vulcan GMS uses a variety of contact cements and epoxies based on the application. Lead can be saw cut, router cut or die cut to produce the lead blank needed for the application. We can use other processes like spinning or forming to generate the needed profiles. Vulcan can apply the sheets or shapes with pressure if needed to ensure a solid bond or expansion. We can also use a variety of techniques to ensure that there are no joints (overlap joints, stop joints, lead burned joints or corner extrusions) which could cause radiation leaks.	1 1

	We also can lead line nearly any application for products such as X-Ray tube housing, X-Ray tunnels, X-Ray tanks and collimators, which are all typically used in the medical X-ray and security markets. **iv)Plastic Lining** Lined tanks are widely used in the finishing industry—especially for corrosives. The lining protects the tank from corrosion and the tank contents from contamination, and the substrate provides structural integrity. In electroplating, the lining also provides electrical insulation.	1
2	**Attempt any four**	**16**
2-a	**Expression for Work done in Reversible Isothermal Expansion of gas** Consider a gas enclosed in a cylinder fitted with a weightless & frictionless piston, undergoing a reversible expansion process. The cylinder is in thermal equilibrium with the surroundings so that the temperature of the gas remains constants while its expansion. The total work done by the gas in the expansion process as the piston moves from position 1to position 2 during which volume is changing from V_1 to V_2(and its pressure is reduced from P_1 to P_2) is given by $W = W_{1-2} = \int_1^2 PdV = \int_{v1}^{v2} PdV$ The work done in reversible isotherm expansion of a gas is given by $W = P\,dV \int_{v1}^{v2} PdV$ (1) The ideal gas equation is	4

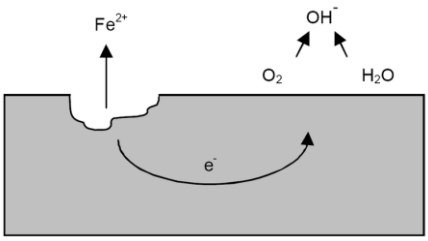
	$PV = nRT$ $P = nRT/V$ (2) Substituting for P from eq (2) eq (1 becomes) $W = \int_{V1}^{V2} (nRT/V)dV = nRT \int_{v1}^{v2} dV/V$ Integrating gives $W = nRT\ln V_2/V_1$ (3) We have $P_1 V_1 = nRT_1$ and $P_2 V_2 = nRT_2$ But $T_1=T_2$---------- For Isothermal Process $P_1V_1 = P_2 V_2$ $V_2/ V_1 = P_1/P_2$ With this, equation (3) becomes $W = nRT\ln P_1/P_2$ $W = nRT\ln V_2/V_1 = nRT\ln P_1/P_2$	
2-b	**Galvanic Cell**:  A galvanic cell consists of two half-cells, such that the electrode of one half-cell is	4

	composed of metal A, and the electrode of the other half-cell is composed of metal B; the redox reactions for the two separate half-cells. The solutions are connected by a salt bridge or a porous plate in order to conduct the ions (both the metal-A cations from one solution, and the anions from the other solution), which balances the charges of the solutions and thereby allows the reaction between metal A and metal B to continue without opposition.Copper readily oxidizes zinc; for the the anode is zinc and the cathode is copper, and the anions in the solutions are sulfates of the respective metals. When an electrically conducting device connects the electrodes, the electrochemical reaction is:. The zinc electrode is dissolved and copper is deposited on the copper electrode.Galvanic cells are typically used as a source of electrical power. By their nature, they produce direct current.	
2-c	**Phase diagram for water system:**  	4

2-d **Diff. Between physical and chemical adsorption:** 1 mark each for any 4

physical adsorption	chemical adsorption
The forces operating in these are weak vander Waal's forces.	The forces operating in these cases are similar to those of a chemical bond.
The heat of adsorption are low i.e. about 20 – 40 kJ mol-1	The heat of adsorption are high i.e. about 40 – 400 kJmol-1
No compound formation takes place in these cases.	Surface compounds are formed.
The process is reversible i.e. desorption of the gas occurs by increasing the temperature or decreasing the pressure.	The process is irreversible. Efforts to free the adsorbed gas give some definite compound.
It does not require any activation energy.	It requires any activation energy.
This type of adsorption decreases with increase of temperature.	This type of adsorption first increases with increase of temperature. The effect is called activated adsorption.
It is not specific in nature i.e. all gases are adsorbed on all solids to some extent.	It is specific in nature and occurs only when there is some possibility of compound formation between the gas

		being adsorbed and the solid adsorbent.	
	The amount of the gas adsorbed is related to the ease of liquefaction of the gas.	There is no such correlation exists.	
	It forms multimolecular layer.	It forms unimolecular layer.	
2-e	**Ductility**: ductility is a solid material's ability to deform under tensile stress; this is often characterized by the material's ability to be stretched into a wire. **Plasticity** : plasticity is the propensity of a material to undergo permanent deformation under load. **Hardness**: Hardness is a measure of how resistant solid matter is to various kinds of permanent shape change when a compressive force is applied. Some materials (e.g. metals) are harder than others (e.g. plastics). Macroscopic hardness is generally characterized by strong intermolecular bonds, but the behavior of solid materials under force is complex; therefore, there are different measurements of hardness: *scratch hardness*, *indentation hardness*, and *rebound hardness*. **Strength**: In materials science, the strength of a material is its ability to withstand an applied load without failure or plastic deformation. The field of strength of materials deals with forces and deformations that result from their acting on a material. A load applied to a mechanical member will induce internal forces within the member called stresses.	1 1 1 1
2-f	**Pitting corrosion**: It is supposed by some that gravitation causes downward-oriented concentration gradient of the dissolved ions in the hole caused by the corrosion, as the	

	concentrated solution is denser. This however is unlikely. The more conventional explanation is that the acidity inside the pit is maintained by the spatial separation of the cathodic and anodic half-reactions, which creates a potential gradient and electromigration of aggressive anions into the pit.This kind of corrosion is extremely insidious, as it causes little loss of material with small effect on its surface, while it damages the deep structures of the metal. The pits on the surface are often obscured by corrosion products.Pitting can be initiated by a small surface defect, being a scratch or a local change in composition, or a damage to protective coating. Polished surfaces display higher resistance to pitting.  **Galvanic corrosion:** Selective leaching, also called dealloying, demetalification, parting and selective corrosion, is a corrosion type in some solid solutionalloys, when in suitable conditions a component of the alloys is preferentially leached from the material. The less noble metal is removed from the alloy by microscopic-scale galvanic corrosion mechanism. The most susceptible alloys are the ones containing metals with high distance between each other in the galvanic series, e.g. copper and zinc in brass. The elements most typically undergoing selective removal are zinc, aluminium, iron,cobalt, chromium and others	2 2
3	**Attempt any four**	**16**
3-a	**Freundlich Adsorption Isotherm**: **Freundlich** gave an empirical expression	

representing the isothermal variation of Adsorption of a quantity of gas adsorbed by unit mass of solid adsorbent with pressure. This equation is known as Freundlich Adsorption Isotherm or Freundlich Adsorption equation.

$$\frac{x}{m} = kP^{\frac{1}{n}}$$

Where x is the mass of the gas adsorbed on mass m of the adsorbent at pressure p and k, n are constants whose values depend upon adsorbent and gas at particular temperature. 3

Explanation of Freundlich Adsorption equation

At low pressure, extent of adsorption is directly proportional to pressure (raised to power one).

$$\frac{x}{m} \propto P^1$$

At high pressure, extent of adsorption is independent of pressure (raised to power zero).

$$\frac{x}{m} \propto P^0$$

Therefore at intermediate value of pressure, adsorption is directly proportional to pressure raised to power 1/n .Here n is a variable whose value is greater than one.

$$\therefore \frac{x}{m} \propto P^{\frac{1}{n}}$$

Using constant of proportionality, k, also known as adsorption constant we get

$$\frac{x}{m} = kP^{\frac{1}{n}}$$

The above equation is known as Freundlich adsorption equation.

Plotting of Freundlich Adsorption Isotherm

As per Freundlich adsorption equation

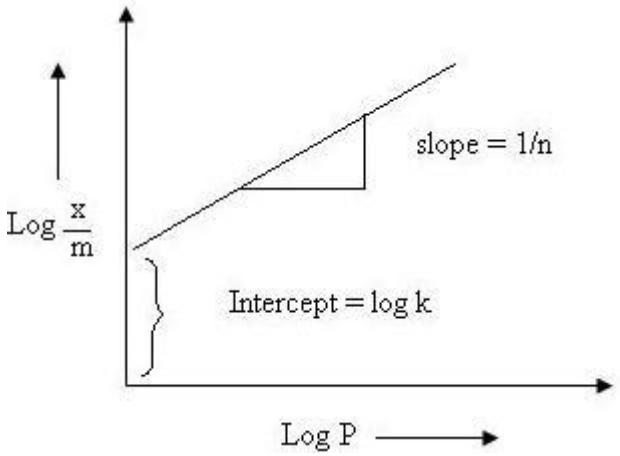
$$\frac{x}{m} = kP^{\frac{1}{n}}$$

Taking log both sides of equation, we get,

$$\log\left(\frac{x}{m}\right) = \log k + \frac{1}{n}\log p$$

The equation above equation is comparable with comparable with equation of straight line, y = m x + c where, m represents slope of the line and c represents intercept on y axis.

Plotting a graph between log(x/m) and log p, we will get a straight line with value of slope equal to 1/n and log k as y-axis intercept.



1

log(x/m) vs. log p graph

Limitation of Freundlich Adsorption Isotherm

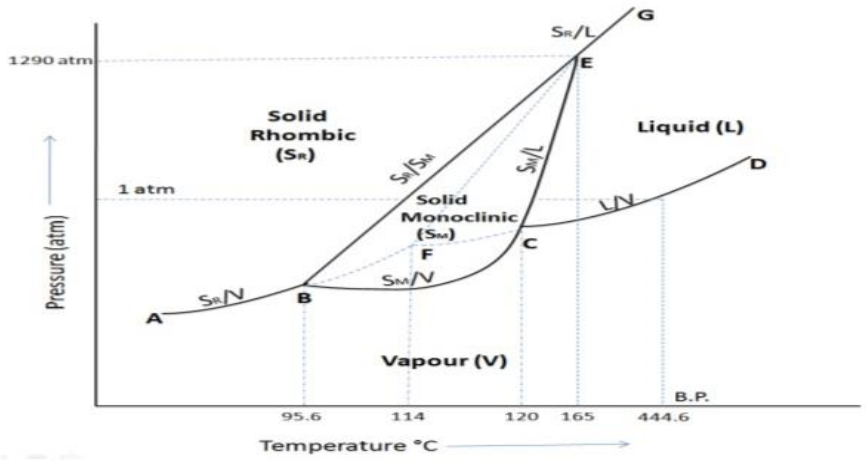
Experimentally it was determined that extent of adsorption varies directly with pressure till saturation pressure Ps is reached. Beyond that point rate of adsorption saturates even after applying higher pressure. Thus Freundlich Adsorption Isotherm failed at higher pressure.

3-b **Lining:**

Lining is a layer of material on the inner surface of something, usually for

	protection or decorative appearance Linings prevent corrosion in a wide range of difficult applications. Linings are commonly used in applications such as: • Cylindrical lining, bushing - A cylindrical metal lining used to reduce friction • Furnace lining, refractory - Lining consisting of material with a high melting point, used to line the inside walls of a furnace • Protective covering - A covering that is intended to protect from damage or injury • Strip lining - Thin sheet strips of corrosion-resistant alloy attached by spot welding in the field to protect an unclad vessel The most commonly used lining materials are polymers, refractories, cement and bricks. Which materials are used for lining depends on the materials and surroundings upon which lining is to be applied.	2 2
3-c	**Second Law of Thermodynamics:** The Second Law of Thermodynamics states that the state of entropy of the entire universe, as an isolated system, will always increase over time. The entropy change of the surroundings and the entropy change of the system itself. Given the entropy change of the universe is equivalent to the sums of the changes in entropy of the system and surroundings: $\Delta S_{univ} = \Delta S_{sys} + \Delta S_{surr} = q_{sys}T + q_{surr}T$ In an isothermal reversible expansion, the heat q absorbed by the system from the surroundings is	2

	qrev=nRTlnV2V1 Since the heat absorbed by the system is the amount lost by the surroundings, qsys=−qsurr.Therefore, for a truly reversible process, the entropy change is ΔSuniv=nRTlnV2V1T+−nRTlnV2V1T=0 If the process is irreversible however, the entropy change is ΔSuniv=nRTlnV2V1T>0 If we put the two equations for ΔSunivtogether for both types of processes, we are left with the second law of thermodynamics, ΔSuniv=ΔSsys+ΔSsurr≥0 where ΔSuniv equals zero for a truly reversible process and is greater than zero for an irreversible process. In reality, however, truly reversible processes never happen (or will take an infinitely long time to happen), so it is safe to say all thermodynamic processes we encounter everyday are irreversible in the direction they occur.	2
3-d	**Homogeneous System:** A homogeneous thermodynamic system is defined as the one whose chemical composition and physical properties are the same in all parts of the system, or change continuously from one point to another. A homogeneous system can be exemplified by imagining a column of atmospheric air, which is a mixture of a number of gases, mainly nitrogen and oxygen. In a system of this kind, acted upon by the force of gravity, both the composition of the system and its physical properties will continuously change from one point to another. A homogeneous system and each phase of a heterogeneous system may consist of one or several pure substances.	2

	Hetrogeneous System: A heterogeneous system is denned as one consisting of two or more homogeneous bodies. An example of a heterogeneous system is water with ice floating in it. This system has two homogeneous bodies, water and ice. The chemical composition of the two phases is the same, but their physical properties differ drastically. Another example of a heterogeneous system is the content of a sealed steel tube containing liquid mercury, liquid ethyl alcohol, and a mixture of saturated vapors of the alcohol and mercury. This heterogeneous system comprises three phases. The first phase is the liquid mercury, the second is the liquid ethyl alcohol, and the third phase is represented by the mixture of saturated vapors. Here the chemical compositions and the physical properties of all phases are different.	2
3-e	**Phase diagram of Sulphur system**: 	4
3-f	**% Composition of SS304**:	2

	C:0.08 Si:0.75 Mn:2 Cr:18 Ni:8 P:0.045 S:0.030 **Properties(any 3)** • High ductility, • excellent drawing, • forming, and • spinning ***properties***.	2
4	**Attempt any four**	**16**
4-a	**Derivation of phase rule** Lets assume that we have a heterogeneous system in equilibrium consisting of C components distributed in P phases . The composition of each phase containing C component is determined by specifying C -1 mole fraction since the some of mole fraction of components present in any phase is equal to 1.If we specify mole fractions of components ,say 2,3,4 …..,then mole fraction of component 1 is obtained as $X_1 = 1-(X_1+X_2+X_3+….)$.Thus as regarding composition, each phase possess C-1 variables. Since there are P phases, it follows that the whole system possesses P(C-1) composition variables. State of the system will depend upon temperature and pressure, these 02 variables are also to be specified .Thus our system of C components and P phases possesses P(C-1) + 2 intensive variables. In order to define the state of system completely ,it is necessary to have as many	4

	equations as there are variables .Since the number of equations is equal to the number of variables ,the number of unknown variables that must be arbitrarily fixed or specified to define the system completely or the number of degree of freedom (F) or variance of the system will be F = Number of variables – Number of Equations =⎡ P(C-1) + 2⎤ - C(p-1) = PC – P + 2 – PC + C **F = C-P + 2**	
4-b	**Applications of Teflon:** 1. Cookware: The nonstick property of Teflon has been used in the manufacture of cookware ever since the discovery of this material. Its extremely low frictional properties and high heat resistance have made Teflon cookware very popular. 2. Machine parts: The extremely low friction of Teflon makes it ideal for making machine parts, such as gears, bearings, pipe linings, joints, slide plates, bushings, O-rings, and saw blades. There is a lot of sliding action in the working of such machine parts. The low friction and self-lubricating property of Teflon decreases wear and tear and increases the life of machinery. 3. Fabric and carpet industry: The nonstick property of Teflon is also used in fabrics and carpets for improving their stain-resistant qualities. 4. Insulator: Teflon has excellent dielectric properties, especially at high radio frequencies. This property is useful for its use as an insulator in cables and connector assemblies.	1 mark each for any 2

	5. Medicine: The chemical inertness of Teflon makes it apt for making artificial body parts. **Applications of Polypropylene:** Is a thermoplastic polymer used in a wide variety of applications including packaging and labeling, textiles (e.g., ropes, thermal underwear and carpets), stationery, plastic parts and reusable containers of various types, laboratory equipment, loudspeakers, automotive components, transvaginal mesh[1] and polymer banknotes. An addition polymer made from the monomer propylene, it is rugged and unusually resistant to many chemical solvents, bases and acids. **Applications of Polyvinyl Chloride**: PVC comes in two basic forms: rigid (sometimes abbreviated as RPVC) and flexible. The rigid form of PVC is used in construction for pipe and in profile applications such as doors and windows. It is also used for bottles, other non-food packaging, and cards (such as bank or membership cards). It can be made softer and more flexible by the addition of plasticizers, the most widely used being phthalates. In this form, it is also used in plumbing, electrical cable insulation, imitation leather, signage, phonograph records,inflatable products, and many applications where it replaces rubber.	1 1
4-c	**i)Enthalpy:** A thermodynamic quantity equivalent to the total heat content of a system. It is equal to the internal energy of the system plus the product of pressure and volume. **ii) Entropy**: In thermodynamics, *entropy* (usual symbol S) is a measure of the number of	1 1

specific realizations or microstates that may realize a thermodynamic system in a *defined* state specified by macroscopic variables. Most understand *entropy* as a measure of molecular disorder within a macroscopic system.

iii) Internal Energy

In thermodynamics, the *internal energy* of a system is the *energy* contained within the system, excluding the kinetic *energy* of motion of the system as a whole and the potential *energy* of the system as a whole due to external force fields. — 1

iv) Chemical potential

In thermodynamics, *chemical potential*, also known as partial molar free energy, is a form of *potential* energy that can be absorbed or released during a *chemical* reaction. — 1

4 d — 1 mark each

Definition	Lyophilic colloids are liquid loving colloids (Lyo means solvent and philic means loving).	Lyophobic colloids are liquid hating colloids (Lyo means solvent and phobic means hating).
Nature of Sub	These sols are usually formed by the organic substances like starch, gum, proteins etc.	These sols are usually formed by the inorganic materials like metals, their sulphides etc.
Viscosity	The lyophilic colloids are highly viscous in nature and have higher viscosity than that of the	The Lyophobic colloids have almost same viscosity as that of medium

			medium.		
		Stability	Lyophilic sols are relatively stable as strong forces of interaction exist between colloidal particles and liquid.	Lyophobic sols are less stable as weak forces of interaction exist between colloidal particles and liquid	
4-e					4

Electroplating:

Electroplating is the process of plating one metal onto another by hydrolysis, most commonly for decorative purposes or to prevent corrosion of a metal. There are also specific types of electroplating such as copper plating, silver plating, and chromium plating. Electroplating allows manufacturers to use inexpensive metals such as steel or zinc for the majority of the product and then apply different metals on the outside to account for appearance, protection, and other properties desired for the product. The surface can be a metal or even plastic.

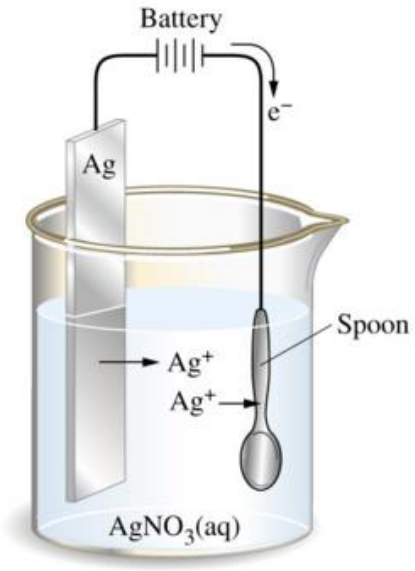
Sometimes finishes are solely decorative such as the products we use indoors or in a dry environment where they are unlikely to suffer from corrosion. These types of products normally have a thin layer of gold, or silver applied so that it has an attractive appeal to the consumer. Electroplating is widely used in industries such as automobile, airplanes, electronics, jewelry, and toys. The overall process of electroplating uses an electrolytic cell, which consists of putting a negative charge on the metal and dipping it into a solution that contains metal salt (electrolytes) which contain positively charged metal ions. Then, due to the negative and positive

charges, the two metals are attracted to each other.

The Purposes of Electroplating:

1. Appearance
2. Protection
3. Special surface properties
4. Engineering or mechanical properties

The cathode would be the piece to be plated and the anode would be either a sacrificial anode or an inert anode, normally either platinum or carbon (graphite form). Sometimes plating occurs on racks or barrels for efficiency when plating many products. Please refer to electrolysis for more information. In the figure below, the Ag^+ ions are being drawn to the surface of the spoon and it eventually becomes plated. The process is undergone using silver as the anode, and a screw as the cathode. The electrons are transferred from the anode to the cathode and is underwent in a solution containing silver.

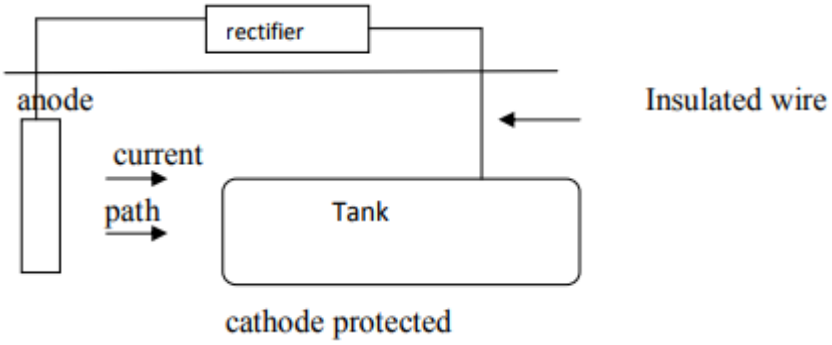
		
4-f	**Purpose of lining** i) chemical resistance, ii) low permeability, iii) physical durability and iv) economical installation.	1 mark each
5	**Answer any 4**	**16**
5-a	**Applications of adsorption**: (any 4) a. in production of high vacuum: b. in gas masks c. in heterogeneous catalysts d. in removing colouring matter from solutions e. in chromatography f. in dehumidification g. in water purification. a) In production of high vacuum: in order to remove traces of air from a partially evacuated container. it is connected to a small bulb filled with activated charcoal or	1 mark each

	silica gel and cooled with a liquid air. The activated charcoal adsorbs the traces of air resulting in the production of very high vacuum in the container. b) In gas masks: gas masks are personal protective devices containing activated charcoal. The activated charcoal removes poisonous, toxic gases from air by adsorption and thus purifies the air for breathing. c) In heterogeneous catalysis : solid catalyzed gas phase reactions proceed through the adsorption of gaseous reactants on the surface of a solid catalyst. d) In removing colouring matter from solutions: animal charcoal removes colours	
5-b	**The different methods to prevent corrosion:** 1) Use of high purity metal. 2) Use of alloy addition. 1) **Use of high purity metal**: The impurities present in a metal cause heterogeneity and form tiny electrochemical cells with rest of the metal. due to this, metal surface undergoes corrosion at the region where the impurities are present .the corrosion resistance of any metal can be improved by increasing the purity of the metal. 2) **Use of alloy addition**: Corrosion resistance as well as strength of metals can be improved by alloying .ex. stainless steel containing chromium produce a coherent oxide film which protects the steel from further attack. **Control:** 1.proper designing and fabrication of componenets 2. use of inhibitors. 3.cathodic protections 4.use of protective surface coatings. 5.special heat treatment.	2 2
5-c	**Open system**: In which exchange of energy or matter takes place across the boundary with its surroundings **Closed system**: In which exchange of energy but not matter takes place across the	2 2

	boundary with its surroundings	
5-d	**MOC for Hydrochloric acid (HCl)** fiberglass-reinforced plastic (FRP) tank **MOC for Sulphuric acid (H_2SO_4)** Store in a metallic or coated fiberboard drum using a strong polyethylene inner package **MOC for Nitric acid (HNO_3)** Aluminium and its alloy **MOC for Caustic soda (NaOH)** Nickel, SS	1 1 1 1
5-e	**Zeroth law of thermodynamics:** If two systems are in thermal equilibrium respectively with a third system, they must be in thermal equilibrium with each other. This law helps define the notion of temperature.	4
5-f	**Langmuir adsorption isotherm**: Langmuir Equation which depicts a relationship between the number of active sites of the surface undergoing adsorption (i.e. extent of adsorption) and pressure. To derive Langmuir equation and new parameter "θ" is introduced. Let θ the number of sites of the surface which are covered with gaseous molecules. Therefore, the fraction of surface which are unoccupied by gaseous molecules will be $(1 - \theta)$. Now, Rate of forward direction depends upon two factors: Number of sited available on the surface of adsorbent, $(1 - \theta)$ and pressure P, Therefore rate of forward reaction is directly proportional to both mentioned factors. Rate of forward reaction α P (1-θ) Rate of adsorption α P (1-θ)	4

	Or Rate of adsorption = $K_a P (1-\theta)$ Similarly, Rate of backward reaction or Rate of Desorption depends upon number of sites occupied by the gaseous molecules on the surface of adsorbent. Rate of desorption $\alpha\ \theta$ Rate of desorption = $K_d \theta$ At equilibrium, rate of adsorption is equal to rate of desorption. $K_a P (1-\theta) = K_d \theta$ We can solve the above equation to write it in terms of θ $K_a P - K_a P\theta = K_d \theta$ $K_a P = K_a P\theta + K_d \theta$ $K_a P = (K_d + K_a P)\theta$ $\theta = K_a P/(K_d + K_a P)$ After dividing numerator and denometer by K_d $\theta = (K_a P/K_d)/((K_d/K_d) + (K_a/K_d) P)$ put $K = K_a/K_d$ $\theta = KP/(1+KP)$ Langmuir Adsorption Equation This is known as Langmuir Adsorption Equation.	
6	**Answer any 4**	**16**
6-a	**Caustic Embrittlement**: Caustic embrittlement is a phenomenon that occurs in boilers where caustic substances accumulate in boiler materials. It also can be described as the cracking of riveted mild steel boiler plates. This occurs at temperatures of 200°-250°C as a result of local deposition of concentrated hydroxide. Caustic embrittlement focuses on the stressed parts of the boiler, including cracks, bends, rivets and joints. Residual sodium carbonate, which is used	4

	for the softening process, undergoes hydrolysis, forming sodium hydroxide at high pressures and temperatures. Caustic embrittlement is also known as stress corrosion cracking. There are many causes of caustic embrittlement, including the combined action of the following three components: • A susceptible material • A given chemical species • Tensile stress Sodium hydroxide (caustic soda) prevents scaling when added to the boiler water. The presence of alkali in the crevices, found around the rivet heads and other hot spots, combined with fabrication stress around rivet holes, causes cracks in the steel boiler shells and tube plates. The alkaline water enters the minute holes and cracks by capillarity action on the interior of the boiler. The water then diffuses out of the cracks, leaving behind hydroxide salts that accumulate when more water evaporates. The hydroxide then attacks the surrounding material of the boiler and dissolves iron as sodium ferrite. This corrosion at high pH levels produces hydrogen, which attacks the crystal structure of iron, making it hard and brittle. This is highly dangerous because the tube can then fail at the boiler's normal operating temperature. Caustic embrittlement can be prevented through several methods, including: • Controlling the temperature and potential • Controlling the stress levels and hardness • Use of materials that do not crack when used in given environments • Avoiding alkali where necessary • Replacing sodium carbonates with sodium sulphates as softening reagents • Adding lignin, tannin or sodium sulphate that blocks hairline cracks as well as preventing infiltration of sodium hydroxide into the areas	
6-b	**Impressed current method for cathodic protection**: Generally underground tanks and pipeline are protected by impressed current method. In this method a rectifier is used to convert AC to DC and this current is applied through an insulted wire through the anode buried in the soil and connected to the corroding tank/pipeline, which is to be protected. The current then flows through the soil to	4

	the tank and returns to the rectifier through and an insulated wire attached to the tank. The tank is protected because the current going to it over comes the corrosion causing current normally flowing away from it.  cathode protected	
6-c	**Equilibrium state:** In thermodynamics, equilibrium state or *state of equilibrium* is a conjunction term describing the state of a system that is in equilibrium, meaning that neither it nor its surroundings are evolving with time. The process of changing a system from one equilibrium state to another generally centers on the meaning or effect of the entropy change ΔS for the process. **Non-Equilibrium state: A** non-equilibrium state refers to the state of existence of a given system or body in which the variation of the thermodynamic potential quantifying the system is not equal to zero. A system or body in a non-equilibrium state means that unbalanced potentials (or driving forces) exist within the system.	2 2
6-d	**Features of electro chemical series(any 4)** a) Instead of standard electrode potentials, actually measured rest potentials of metals and alloys in a given environment arranged with respect to nobility and activity. b) Practically measured potentials vs reference electrode. c) Effect of coupling of metals and alloys on corrosion rate can be predicted. d) The galvanic series (or electro potential series) determines the nobility of metals	1 mark each

	and semi-metals. e) The rate of corrosion is determined by the electrolyte and the difference in nobility.	
6-e	**Oxide film**: It is the corrosion due to chemical attack of oxygen in a dry environment at low or high temperature. it results in the formation of metal oxide layer on the metal surface. The nature of oxide film formed decides the prevention or continuation of corrosion. The oxide film produced based on its nature can be classified as: Stable oxide film, unstable and volatile film. **Stable oxide film**: it acts as barrier between metal and oxygen and thus prevents further corrosion. Stable oxide film may be **porous** or **non porous** in nature .in case of porous oxide film permits free access of of oxygen to the metal surface. in the case of non porous film their are no pores or cracks in the oxide film for further corrosion. **Unstable oxide film**: the film formed decomposes back to the metal and oxygen. Hence oxidation corrosion is not possible in case of noble metals. **Volatile oxide film**: in this case the film formed vaporizes / volatiles as soon as it is formed and the metal surface is exposed to further corrosion. it leads to continues and excessive corrosion.	4
6-f	**System**: The specified portion of the universe containing a definite quantity/amount of a specific substance or group of substances under thermodynamic study is called a system. **Surrounding:** The part of the universe other than the system which is separated from the system by a boundary is called the surroundings. Everything external to the system is called surroundings. **Boundary:** A boundary is a closed surface surrounding a system through which energy and mass may enter or leave the system	1 2 1