SUMMER-14 EXAMINATION

Model Answer

Important Instructions to examiners:

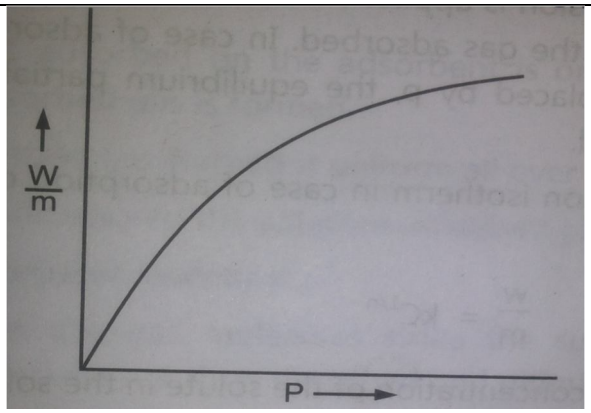
1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling 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.

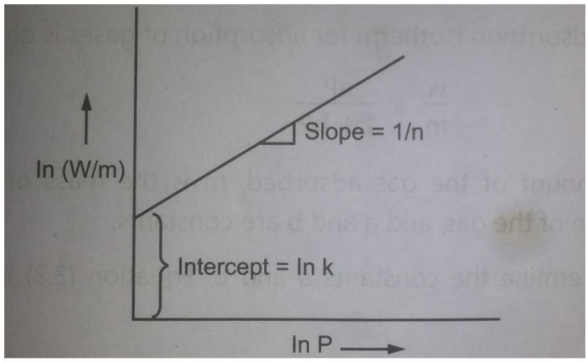
Q No.	Answer	marks	Total marks
1a-i	**Reversible process-** A Process in which direction may be reversed at any stage, by merely small change in the state variable, restoring the system and surrounding to their original state is called a reversible process. **Irreversible Process-** A process which do not satisfy the conditions of reversibility is called as an irreversible process. In this process, the change is carried out fast with a measurable speed so that the system can not attain thermodynamic equilibrium. All natural process are reversible.	1 1	2
1a-ii	**Types of Adsorption** 1 Physical Adsorption. Eg Adsorption of hydrogen or oxygen on charcoal. 2 Chemisorption. Eg Hydrogen is chemisorbed on nickel, NO_2 is absorbed in water to get HNO_3	1 mark each	2
1a-iii	**Effect of temperature on corrosion** The rate of corrosion increases with the increase in temperature. Eg. Corrosion of iron & steel increases with the increase in temperature.	1 1	2
1a-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, P is the number of phases in thermodynamic equilibrium with each other and	2	2

	F is the number of degrees of freedom or variance of the system.		
1a-v	**Statements of first law of thermodynamics** 1. Whenever a certain quantity of one kind energy disappears, an exactly equivalent amount of some other kind must appear. 2. It is not possible to construct a perpetual motion machine which can produce work without consuming energy. 3. The total energy of an isolated system always remains constant. 4. The sum of the energy in the universe is constants. 5. In an open system, there is always exchange of energy between the system and the surroundings but its sum is constant at all times. Expression for first law of thermodynamics $\Delta Q = \Delta U + W$ Where Q – Heat absorbed by the system. U – Increase in internal energy of the system. W – Work done by the system.	1 mark for 1 statement & 1 mark for expression	2
1a-vi	**Uses of PVC** 1. It is used for pipes, pipe fittings, valves. 2. It is used for storage tanks, reaction vessel, scrubbers. 3. It is used for ducts, vents, safety helmets. 4. It is used for tank lining & sewage piping. **Uses of Polyethylene** 1. It is used for tanks, industrial containers, drums. 2. It is used for pipes, valves, fittings. 3. It is used for hard hats, jacketing, caps & closures. 4. It is used for packaging films & oil & gas lines.	1 1	2

1a-vii	**Meaning of electrode potential –** Electrode potential of a metal (electrode) is the potential difference between the electrode and its solution. OR When a metal (electrode) is immersed in a solution of its ions, a potentials difference is set up between the metal & ions of the metal in the solutions. This potential is knows as electrode potential	2	2
1b-i	**Importance of Lining** In order to attain certain desired features, the base metal may be lined with another metal, rubber, glass & plastic. Lining mild steel pipe with a material able to withstand chemical attack permits its used to carry corrosive fluids. Lining give the underlying structure protection against chemical attack. It prevents contamination of metal. Due to lining effect of abrasion can be reduced. It also provides high mechanical strength to the metal. **Types of lining** 1.Lead lining 2.Glass lining 3.Rubber lining 4.plastic lining	2 2	4
1b-ii	**Types of corrosion** A) Dry Corrosion or chemical corrosion. i) corrosion by oxygen or oxidation corrosion. ii) corrosion by (due to)other gases. B) Wet corrosion or electrochemical corrosion. **Oxidation Corrosion** Oxidation corrosion is the corrosion of a metal due to chemical attack in a dry environment at low or high temperature. It results in the formation of metal	2 2	4

	oxide layer on the metal surface according to the following reaction: $2M + nO_2 \longrightarrow 2MO_n$ (metal) (metal oxide) Initially a thin layer of oxide film is formed & it gradually grows with time. The nature of metal oxide film/layer formed decides the prevention or continuation of corrosion. ***Any other type of corrosion written by the student should be considered.***		
1b-iii	**Freundlich Adsorption Isotherm** The Freundlich adsorption isotherm for adsorption of gases is represented by the equation: $w/m = k\ p^{1/n}$ Where w is the mass of the gas adsorbed at a pressure P m is the mass of the adsorbent & k & n are constants, which depend on the nature of the gas & adsorbent & the tempratuer. This equation is generally represented graphically in the form of a curve by plotting the mass of the gas adsorbed per unit mass of the adsorbent i.e. w/m v/s equillibrium pressure, P of the gas. If we plot (w/m) v/s P, We get a smooth curve as shown in fig	2	4





2 marks

The values of k & n can be determined by plotting

ln (w/m) v/s ln P.

Taking the logarithms of both sides of equation (1) gives

Ln (w/m) = ln k + 1/n ln p

Ln (w/m) = 1/n ln p + ln k $\Longrightarrow$ y= mx+c

A plot of ln (w/m) v/s ln p yields a straight line with a slope equal to 1/n and an intercept equal to ln k.

Slope = 1/n , n= 1/Slope

Intercept = lnk , k = $e^{(\text{Intercept})}$

Actually , the plot of lan (w/m) v/s ln p is a straight line upto moderate pressure and is slightly curved at high pressures.The Freundlich adsorption isotherm

	holds good upto moderate pressures of gases If the experimental adsorption data are plotted as ln (w/m) v/s ln p and if this plot comes out to be a straight line then the Freundlich adsorption isotherm is verified – we say that the data fit the Freundlich adsorption isotherm.		
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 $PV = nRT$ $P = nRT/V$ (2) Substituting for P from eq (2) eq (1 becomes) $W = \int_{V1}^{V2} (nRT/V)dV = nRT \int_{v1}^{v2} dV/V$	4	4

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 = $nRT\ln V_2/V_1 = nRT\ln P_1/P_2$

Since for an isothermal process , $\triangle U = 0$ and $\triangle T = 0$,

Hence $\triangle H = 0$

We have $\triangle U = Q - W$

For an Isothermal Process $\triangle U = 0$.Therefore, the first law becomes $0 = Q-W$

$Q = W$

Thus, In an isothermal process ,Heat absorbed by a system gets completely converted into work or the work is done at the expense of heat absorbed and the temperature remains constant.

Work done in isothermal reversible expansion of an ideal gas is given by

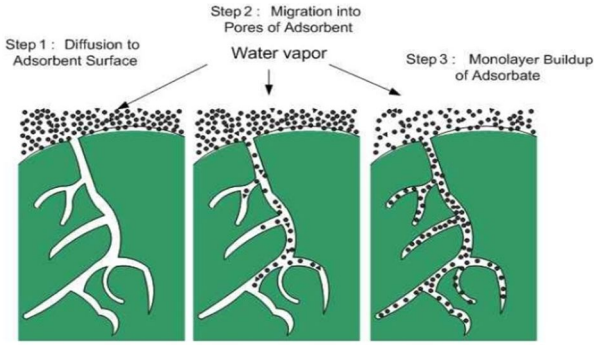
$W = nRT\ln V_2/V_1 = nRT\ln P_1/P_2$

2-b	**(i)Use of High Purity Metals** It is one of the method of preventing corrosion of metals. The impurities present in a metal cause heterogeneity and form tiny electrochemical cells with rest of the metal .Due to this , metal surfaces undergoes corrosion at the region where the impurities are present The impurities present in a metal is one of the main reasons for the corrosion of the metal. Hence ,corrosion resistance of any metal can be improved by increasing the purity of the metal. Generally pure metal does not corrode, since the metal as a pure there is no cathode spot available to induce corrosion **(ii)Use of Alloy Additions** The corrosion resistance of many metals can be increased by alloying them with suitable alloying elements. Corrosion resistance as well as strength of many metals can be improved by alloying for example ,Stainless containing chromium produce a coherent oxide film which protects the steel form further attack. The corrosion resistance increases with increasing alloying content. The stainless steel -316 is more corrosion resistant than stainless steel - 304	2 2	4
2-c	**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.	4	4

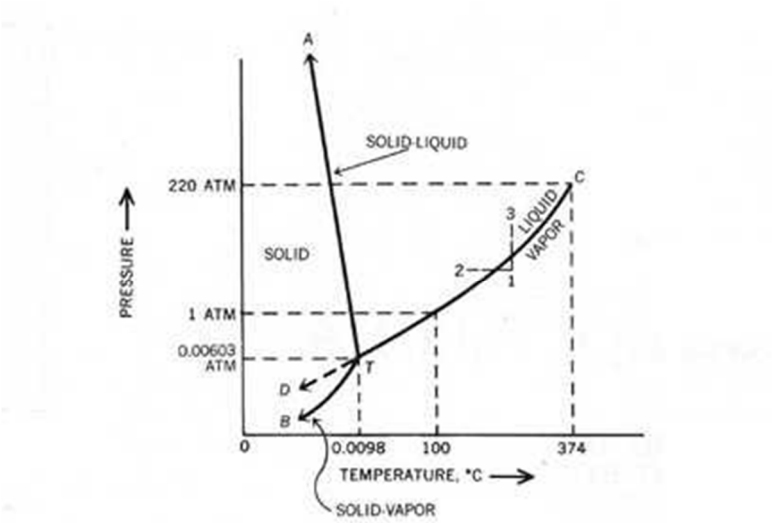
	State of the system will depend upon temperature and pressure, these 02 variables are also to be specified .Thus our system of C components and P phases possesses P(C-1) + 2 intensive variables. In order to define the state of system completely ,it is necessary to have as many equations as there are 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**		
2-d	**Distinguish between Lyophilic and Lyophobic Colloids** 1) Lyophilic Collides are those in which the dispersed phase has a definite affinity for the dispersion medium. 1) Lyophobic Collides are those in which the dispersed phase has no affinity for the dispersion medium. 2) Lyophilic Collides are the solution of organic substance like starch , gum and proteins 2) Lyophobic Collides are the solution of inorganic substance like gold, platinum, iron and arsenic 3) Lyophilic Collides can be prepared directly by mixing the solid material with the liquid dispersion medium 3) Lyophobic Collides cannot be prepared directly by mixing and special methods are used for their preparation 4) The viscosity of a Lyophilic collides is much higher than that of dispersion medium	1 marks each for any four distinguish Points	4

	4) The viscosity of a Lyophobic collides is the same as that of dispersion medium 5) The particles of Lyophilic collides are not visible even under ultra-microscope 5) The particles of Lyophobic collides are visible under ultra-microscope 6) Lyophilic Collides are highly hydrated 6) Lyophobic Collides are not much hydrated		
2-e	**Examples of Commonly used Material of Constructions** 1) Cast Iron Gray – Gray Cast Iron, White cast Iron 2) Mild Steel 3) Stainless Steel- SS-304,SS-316,SS-314 4) Aluminum and its alloys 5) Plastics- PVC,PTFE-Teflon, PP,HDPE **Uses of SS-304** It is used for Process Equipment's, Piping, valves, Fittings and flanges in milk processing, wine making, Fruit juice and chemical industry. In chemical industry it is used for process equipment's for nitration plants. It is used for storage tanks ,tankers and containers. **Uses of SS-316** It is used for making furnace parts ,Heat exchanger tubing and coil, reactors ,digesters, tank , Distillation column, pharmaceutical equipment's and pulp paper and textile processing equipment	02 Marks for any four material 1 mark for any2 1 mark for any2	4
2-f	**Mechanism of Dry Corrosion** Oxidation Corrosion Oxidation corrosion is the corrosion of a metal due to chemical attack in a dry environment at low or high temperature. It results in the formation of metal oxide layer on the metal surface according to the following reaction:	4	4

	$2M + nO_2 \longrightarrow 2MO_n$ (metal) (metal oxide) Initially a thin layer of oxide film is formed & it gradually grows with time. The nature of metal oxide film/layer formed decides the prevention or continuation of corrosion.		
3-a	**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. **Adiabatic process:** An adiabatic process is a process that occurs without the transfer of heat or matter between a system and its surroundings. Adiabatic processes are primarily and exactly defined for a system contained by walls that are completely thermally insulating and impermeable to matter; such walls are said to be adiabatic. **Isobaric process:** An isobaric process is a thermodynamic process in which the pressure stays constant: $\Delta P = 0$. **Isochoric process:** An isochoric process, also called a constant-volume process, an isovolumetric process, or an isometric process, is a thermodynamic process during which the volume of the closed system undergoing such a process remains constant. An isochoric thermodynamic process is characterized by constant volume, i.e., .$\Delta V=0$	1 1 1 1	4

3-b	**Adsorption:** Adsorption is the adhesion of atoms, ions, or molecules from a gas, liquid, or dissolved solid to a surface. This process creates a film of the adsorbate on the surface of the adsorbent. **Mechanism of Adsorption:**  It is mainly divided into three steps as follows ▸ Step 1 : Molecule diffusion process into the thin layer of fluid(Called as fluid film) which is attached on the adsorbent. ▸ Step 2 : According to developing of diffusion, the surface diffusion process which attached the vapour or gas along the pores. It is called as mixed diffusion because there exist two diffusion of pore diffusion and surface diffusion. ▸ Step 3 : Adsorption process in the pore adsorption sites.	1 3	4
3-c	**Criteria for selection of MOC in Chemical Industries** Following are the primary criteria for materials selection 1.Strength: The material must be sufficiently strong to withstand indefinitely the pressure difference between the inside of the equipment and the exterior. 2.Ease of fabrication: ductility, weldability, castability. 3.Resistance to mechanical and thermal shock: A sudden blow or a	½ mark each for any 8	4

	continuously applied stress can cause a brittle material to fail catastrophically, i.e. fracture. A sudden change in temperature can induce a stress sufficient to damage some materials. Ductility is the ability of a material to deform without failing, e.g. by cracks or fracture. 4.Tendency to form sparks:Because leaks do sometimes develop, when a combustible gas is processed in a unit one must avoid sparks. For this reason, in such a unit constructed of steel, brass tools are supplied to maintenance personnel. 5.Corrosion and chemical resistance: 6. Oxidation resistance The exterior of some materials exposed to air will oxidize, particularly as temperature is increased 7.Chemical compatibility: While unusual, one must be alert to the possibility that a material or its oxide can catalyze a dangerous reaction 8.Temperature stability: Temperature influences all of the factors above, generally decreasing strength, increasing ductility, and increasing the rate of chemical reactions. 9.Cost:Typically a variety of suitable materials can be identified for a particular application. The sensible thing then is to choose that with the lowest total cost, not just the cost of the bulk material but including also the cost of fabrication and installation.		
3-d	N=1 mol V_1=2.28 m3 V_2=4.56 m3 R=8.314 J/mol k W=nRTln(V_2/V_1) =1*8.314*300*ln(4.56/2.28) =**1728.84 J**	1 1	4

	As the process is isothermal internal energy is zero $\triangle$ **E=0** As per first low of thermodynamics $\triangle$ E=Q-W 0=Q-W W=Q Q=**1728.84 J**	1 1	
3-e	**Phase diagram for water system:**  Triple point is the intersection on a phase diagram where three phases coexist in equilibrium. The most important application of triple point is water, where the three-phase equilibrium point consists of ice, liquid, and vapor Take the line TC which gives the vapor pressure of liquid water up to the critical point C. Along this line, liquid and vapor coexist in equilibrium. At temperatures higher than that of point C, condensation does not occur at any pressure.	2 2	4

	The line TA represents the vapor pressure of solid ice, which is a plot of the temperatures and pressures at which the solid and vapor are in equilibrium. Finally, line TB gives the melting point of ice and liquid water. The plot shows the temperatures and pressures at which ice and liquid water are in equilibrium. (Note: At the dashed line TD, liquid water can be cooled below the freezing point to give super cooled water.) The preceding paragraphs show that two phases are in equilibrium along the three solid lines. But when these lines intersect at one point C, three phases coexist in equilibrium. This intersection is the triple point, where a substance may simultaneously melt, evaporate, and sublime.		
3-f	**Plastic Lining:** Poly-ethylene, polyvinyl chloride, epoxy etc. are the plastic material used fro plastic lining. Process-plastic lining involved cleaning of metal surface, application of adhesive/bonding agent. And lining with requisite sheets. The joints between sheets are filled up with resin. Other methods: The object to be coated is heated above the melting point of the thermoplast and immersed in a fluidized bed of finely divided polymer.	4	4
4-a	**ADVANTAGES OF GIBBS PHASE RULE** This equation gives the phase rule given by Willard Gibb's, the fundamental relation controlling the equilibria in heterogeneous systems. Advantages of	½ mark each for any four	4

	phase rule: (a) It gives a simple method of classifying equilibrium states of systems. (b) It confirms that the different systems having the same number of degrees of freedom behave in like manner. (c) It predicts the behavior of systems when subjected to changes in the variables such as pressure, temperature and volume. (d) The phase rule is applicable to macroscopic systems. Therefore, it is not necessary to take into account about their molecular structures. (e) It is applicable to physical as well as chemical reactions. (f) Phase rule takes no account of nature of the reactants or the products in phase reactions. (g) Phase rule predicts that a number of substances would remain in equilibrium if some of the substances have been transformed into the new substances. **LIMITATIONS OF PHASE RULE** (a) As the phase rule is applicable to heterogeneous systems in equilibrium, it is therefore of no use for such systems which are slow in reaching the equilibrium state. (b) As the phase rule is applicable to a single equilibrium state, it never tells about the number of other equilibrium possible in the system.	½ mark each for any four	

	(c) In phase rule, various variables are temperature, pressure and composition. This phase rule does not consider the electric or magnetic influences. If such variables are considered, the factor 2 of the phase rule has to be adjusted accordingly. (d) All the phases in the system must be present under the same pressure, temperature and gravitational force. (e) No liquid or solid phases should be finely divided otherwise their vapour pressures will differ from their normal values.		
4-b	**The galvanic series :** The **galvanic series** (or **electropotential series**) determines the nobility of metals and semi-metals. When two metals are submerged in an electrolyte, while electrically connected, the less noble (base) will experience galvanic corrosion. The rate of corrosion is determined by the electrolyte and the difference in nobility. The difference can be measured as a difference in voltage potential. Galvanic reaction is the principle upon which batteries are based. **GALVANIC SERIES of Dissimilar Metals.** **Largest, corrosive part, positive.** 1. Magnesium 2. Ninc 3. Cadmlum 4. Aluminum 5. Steel 6. Iron 7. Stainless-Steel	2 2	4

	8. Solder 9. Lead 10. Tin 11. Nickel 12. Brass 13. Copper 14. Bronze 15. Silver Solder 16. Silver 17. Titanium 18. Graphite 19. Gold 20. Platinum **Smallest, protected part, negative**		
4-c	Enthalpy is a defined thermodynamic potential, designated by the letter "H", that consists of the internal energy of the system (U) plus the product of pressure (P) and volume (V) of the system $H = U + PV$ Since enthalpy, H, consists of internal energy, U, plus the product of pressure (P) and the volume (V) of the system, which are all functions of the state of the thermodynamic system, enthalpy is a state function. The enthalpy of a homogeneous system is defined as $H = U + pV$	1 3	4

where

H is the enthalpy of the system
U is the internal energy of the system
p is the pressure of the system
V is the volume of the system.

The enthalpy is an extensive property. This means that, for homogeneous systems, the enthalpy is proportional to the size of the system. It is convenient to introduce the specific enthalpy h =H/m where m is the mass of the system, or the molar enthalpy H_m = H/n, where n is the number of moles (h and H_m are intensive properties). For inhomogeneous systems the enthalpy is the sum of the enthalpies of the composing subsystems

$$H = \Sigma_k H_k$$

where the label k refers to the various subsystems. In case of continuously varying p, T, and/or composition the summation becomes an integral:

$$H = \int \rho h \mathrm{d}V,$$

where ρ is the density.

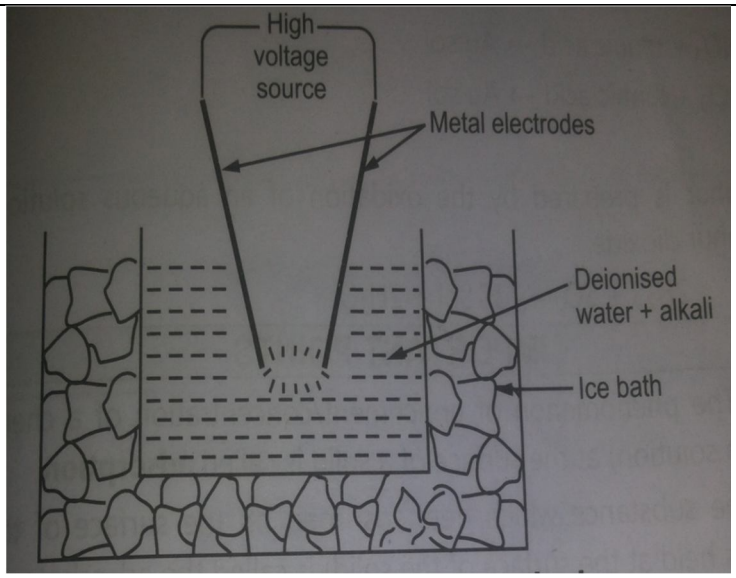
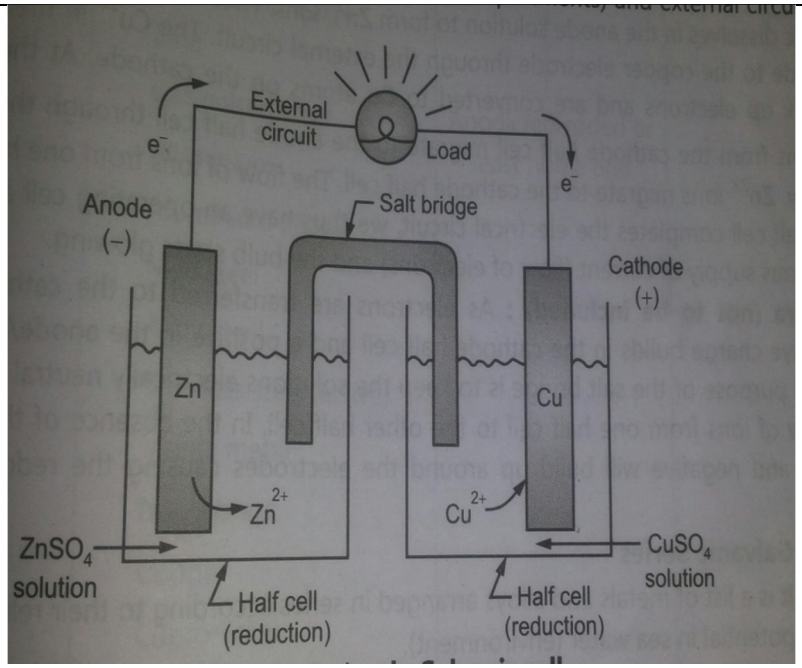
The enthalpy H(S,p) of homogeneous systems can be derived as a characteristic function of the entropy S and the pressure p as follows: we start from the first law of thermodynamics for closed systems for an infinitesimal process

	$dU = \delta Q - \delta W.$ Here, δQ is a small amount of heat added to the system and δW a small amount of work performed by the system. In a homogeneous system only reversible processes can take place so the second law of thermodynamics gives δQ = TdS with T the absolute temperature of the system. Furthermore, if only pV work is done, δW = pdV. As a result $dU = TdS - pdV.$ Adding d(pV) to both sides of this expression gives $dU + d(pV) = TdS - pdV + d(pV)$ or $d(U + pV) = TdS + Vdp.$ So $dH(S,p) = TdS + Vdp.$		
4-d	**physical adsorption (physisorption)** arises due to weak van der waal's forces not specific in nature reversible **chemical adsorption(chemisorption)** due to chemical bond formation highly specific in nature irreversible	½ mark each for any 8	4

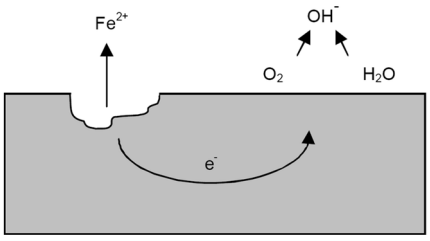
	depends on nature of gas — it also depends enthalpy of adsorption is low — here high takes place low temp. — high dec. with inc. in temp. — inc. with inc. in temp. no appreciable activation energy needed — high activation energy needed depends on surface area — depends on surface area inc. with inc. in surface area — it also inc. results in multimolecular layers — unimolecular layer		
4-e	Material selection is a process which is performed to select the best materials which may have the potential to perform well both in industrially and commercially. Today selection of materials is an important part of industrial designs because the competition in the market is heavy. Failures arising from bad material selection are not uncommon in many industries. In an application that demands a high tensile strength, a material with higher tensile strength must be selected. If the product is to be used outdoors, it may be necessary to consider the effect of ultraviolet light. If a proper material selection is not done, the product life tends to be highly unpredictable. Therefore the material selection process is quite important for the long term success of engineering applications. No material is resistant to all corrosive situations but materials selection is critical to preventing many types of failures Factors that influence materials selection are corrosion resistance in the	4	4

	environment, availability of design and test data, mechanical properties, cost, availability, maintainability, compatibility with other system components, life expectancy, reliability, and appearance. Appropriate system design is also important for effective corrosion control, and includes the consideration of many factors, such as materials selection, process and construction parameters, geometry for drainage, avoidance or electrical separation of dissimilar metals, avoiding or sealing of crevices, corrosion allowance, operating lifetime, and maintenance and inspection requirements		
4-f	**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: 1) 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. 2) 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:** 1) Reactor 2) Acid storage tank 3) Pipeline 4) Column	2 2	4

5-a	**Methods for preparation of colloidal solution** A) Dispersion methods i) Mechanical dispersion ii) Electrical dispersion iii) Peptization B) Aggregation methods i) Double decomposition ii) Reduction iii) Oxidation **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.	2 marks for methods & 2 marks for explanation	4

	 ***Any other method explained by the student should be given marks***		
5-b		4 marks	4
5-c	**Second law of thermodynamics** 1)Heat or in general any type of energy flows from a higher level to a lower level.	2	4

	Eg When two bodies are at different temperatures, heat flows from a hot body to a relatively cold body. **Zeroth law of thermodynamics** It states that if two bodies are separately in thermal equilibrium with a third body, then they are also in thermal equilibrium with each other . Eg If a body A is in thermal equilibrium with a body C & a body B is in thermal equilibrium with body C, then the bodies A & B are also in thermal equilibrium with each other.	2	
5-d	**Application of** **i) Carbon steel** – It used for radiant tubes, heat treatment components, annealing & carburizing boxes. **ii)Teflon** -It is used for gaskets, pumps seal, bushes, agitator shaft/shaft lining, washers, coating filter plates, tank, vessel & reaction vessel lining. **iii) Alloys of aluminum** - It is used in air craft industry, cable –sheathing , in marine application, cryogenic equipments & tanks for jet fuels. **iv)Polypropylene** – It is used for pumps, valves, fittings & pipes. Also used for tanks, ID & FD fans, reaction vessels, filter press, scrubbers, filter press, scrubbers, filter cloth, crates & trays.	1 1 1 1	4
5-e	Solution – $W = nRT\ln P_1/P_2$ $W = 0.5 \times 8.314 \times 300 \ln 1.01325\times10^3/1.01325 \times 10^5$ $W = -5743.10$ J	4	4
5-f	**Characteristics of Lyophilic & Lyophobic colloids** 1. The size of particles ranges from 10 A^0 to 2000 A^0 2. Particles do not diffuse through parchment membrane. 3. Particles pass through filter paper. 4. Particles scatter light.	1 mark each for any four	4

	5. Particles are invisible even under a powerful microscope but a scattering effect can be observed under ultra microscope.		
6-a	**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.  **Selective corrosion:** Selective leaching, also called dealloying, demetalification, parting and selective corrosion, is a corrosion type in some solid solution alloys, when in	2 2	4

	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		
6-b	**Langmuir Adsorption Isotherm** In 1916, Irving Langmuir published a new model isotherm for gases adsorbed to solids, which retained his name. It is a semi-empirical isotherm derived from a proposed kinetic mechanism. This isotherm was based on different assumptions one of which is that dynamic equilibrium exists between adsorbed gaseous molecules and the free gaseous molecules. It is based on four assumptions: 1. The surface of the adsorbent is uniform, that is, all the adsorption sites are equivalent. 2. Adsorbed molecules do not interact. 3. All adsorption occurs through the same mechanism. 4. At the maximum adsorption, only a monolayer is formed: molecules of adsorbate do not deposit on other, already adsorbed, molecules of adsorbate, only on the free surface of the adsorbent. Langmuir suggested that adsorption takes place through this mechanism:	4	4

$$A\,(g) + B\,(s) \underset{\text{Desorption}}{\overset{\text{Adsorption}}{\rightleftharpoons}} AB$$

Where ,

A(g) = unadsorbed gaseous molecule

B(s) = unoccupied metal surface

AB = Adsorbed gaseous molecule.

The direct and inverse rate constants are k and k^{-1}

Based on his theory, Langmuir derived an equation which explained the relationship between the number of active sites of the surface undergoing adsorption and pressure. This equation is called Langmuir Equation.

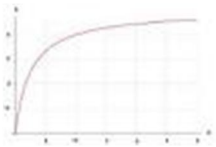
$$\theta = \frac{KP}{1+KP}$$

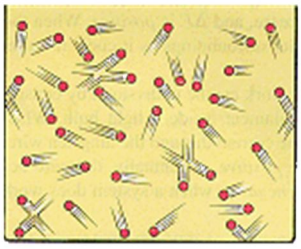
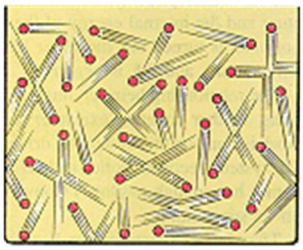
Where, θ= the number of sites of the surface which are covered with gaseous molecule,

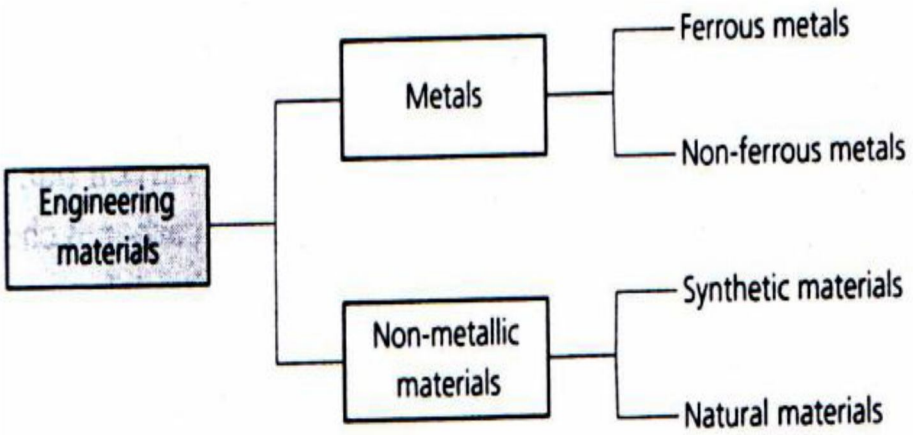
P= pressure

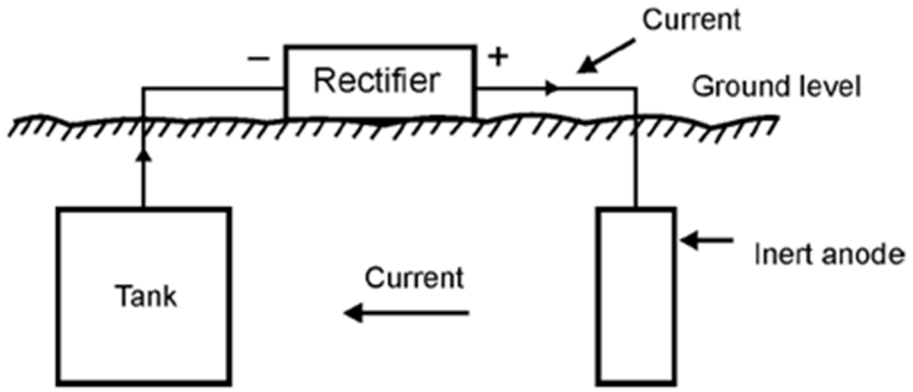
K =is the equilibrium constant for distribution of adsorbate between the surface and the gas phase .

The basic limitation of Langmuir adsorption equation is that it is valid at low

	pressure only. At lower pressure, KP is so small, that factor (1+KP) in denominator can almost be ignored. So Langmuir equation reduces to $\theta = KP$ At high pressure KP is so large, that factor (1+KP) in denominator is nearly equal to KP. So Langmuir equation reduces to $\theta = \frac{KP}{KP} = 1$ 		
6-c	**Cyclic process:** When a system returns to its original state after completing a series of changes, then it is known that a cycle is completed. This process is known as cyclic process. In a cyclic process the initial and the final state is same. As the internal energy U of the system depends only on the state of the system so in a cyclic process the net change of internal energy ΔU will be equal to zero i.e. ΔU = 0. Hence from the first law: ΔU = 0 = q + w Hence, q = – w If the process is taking place at constant temperature then the cycle is known as isothermal cycle. If the process is taking place reversibly then cycle is known as	2	4

	reversible cycle. Example of the cyclic process: The Carnot cycle **Internal Energy** One of the thermodynamic properties of a system is its internal energy, *E*, which is the sum of the kinetic and potential energies of the particles that form the system. The internal energy of a system can be understood by examining the simplest possible system: an ideal gas. Because the particles in an ideal gas do not interact, this system has no potential energy. The internal energy of an ideal gas is therefore the sum of the kinetic energies of the particles in the gas. The kinetic molecular theory assumes that the temperature of a gas is directly proportional to the average kinetic energy of its particles, as shown in the figure   Low Temperature High Temperature	2	
6-d	**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	2	4

	identifying unknown substances. **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	2	
6-e	**Classification of Engineering materials** :  	4	4
6-f	Cathodic Protection a) Cathodic protection is achieved by supplying electrons to the metal structure to be protected i.e. making cathode to the component to be protected. Addition of electrons to the component tends to suppress its dissolution. Two methods are used for cathodic protection. 1) Impressed current method and 2) Use of sacrificial Anode. Usually, underground tanks and pipes are protected by impressed current method(Fig. 1).	1	4

	 Figure 1 Impressed current method for cathodic protection of an underground tank. In this method, an external d. c. power supply is used. The. negative terminal of power supply is connected to underground component and positive to an inert anode. e. g. graphite. Therefore, current passes to component and corrosion is suppressed.	3	