WINTER-15 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.

<table>
<tr><th>Q No.</th><th>Answer</th><th>marks</th><th>Total marks</th></tr>
<tr><td>1a-i</td><td>

Difference between extensive and intensive properties.

<table>
<tr><td>Extensive properties</td><td>Intensive properties</td></tr>
<tr><td>It is depending on the mass of the system</td><td>It is independent of mass /amount of the system</td></tr>
<tr><td>It depends on the amount/quantity of the substance present in the system.
These are additive.</td><td>These are not depending on the size of the system.
These are not additive.</td></tr>
<tr><td>Volume will be different at the stages of the system</td><td>The value of the property is the same at all points.</td></tr>
<tr><td>EX:mass,size</td><td>Ex:internal energy,enthalpy,entropyetc</td></tr>
</table>

</td><td>1 mark each for any one difference 1mark for example.</td><td>2</td></tr>
<tr><td>1a-ii</td><td>

Colloidal sols:A system in which the size of the particles of a substance dispersed in a solvent lies in the range of 10 A^O - 2000 A^O is called a colloidal solution or simply a collide.

</td><td>2</td><td>2</td></tr>
<tr><td>1a-iii</td><td>

The types of corrosion are:
a) dry corrosion or chemical corrosion
1) corrosion by oxygen
2) Corrosion by other gases.
b) wet corrosion or electrochemical corrosion.

</td><td>1

1</td><td>2</td></tr>
<tr><td>1a-iv</td><td>

The phase rule states that the number of degrees of freedom in a physical system at equilibrium is equal to the number of components in the system minus the number of phase plus the constant2.mathematically ,it is stated as follows:

$$F = C - P + 2$$

</td><td>2</td><td>2</td></tr>
</table>

	C - number of components, P -number of phases F – number of degrees of freedom.		
1a-v	**The first law of thermodynamics** states that energy neither be created nor destroyed during process, although it may be converted from one form to another. Let Q be the amount of heat absorbed by a system from the surroundings while undergoing a change from state 1 to state2. the absorption of heat by the system results in performance of some work W, by the system and an increase energy, ΔU of the system, therefore, $Q=\Delta U + W$ $\Delta U = Q - W$	2	2
1a-vi	The composition and uses of **cast iron:** Uses: a) used for caustic fusion pots b) used in pumps and valves & water piping,filter presses.,vaccum pumps.blowers,gears,jaw crushers,centrifuges etc.	1 mark each	2
1a-vii	The rate of corrosion increases with the increase in temperature. For most chemical reactions, the reaction rate increases with increasing temperature. 1. Temperature affects the corrosion rate of metals in electrolytes primari through its effect on factors which control the diffusion rate of oxygen. 2. The corrosion of iron and steel is an example of this because temperature affects the corrosion rate by virtue of its effect on the oxygen solubility and oxygen diffusion coefficient. 3. As temperature increases the diffusion coefficient of oxygen also	2 marks for any 2	2

	increases which tends to increase the corrosion rate. 4. The net affect fo mild steel, is that the corrosion rate approximately doubles for a temperature rise of 30°C up to a maximum temperature at about 80°C, the rate then falls off in an open system because the decreall in oxyben solubility becomes the most important factor. In a closed system, where oxygen cannot escape the corrosion rate continues to increase indefinitely with temperature until all the oxygen		
1b-i	**Comparison between Lyophilic & Lyophobic colloids**	1 mark each for any 4	4

Lyophilic	Lyophobic
They have a definite affinity for the dispersion medium	They have no affinity for dispersion medium
These are organic substances like starch, gum& proteins	These are of inorganic substances like gold, platinum,iron & arsenic.
These can be prepared directly by mixing solid material with liquid dispersion medium.	These can be prepared directly by mixing and special methods are used for their preparation.
Viscosity is higher than that of the dispersion medium	Viscosity of sols is same as that of the medium.
Their particles are not visible even under ultra microscope	These particles are visible under ultra microscope
The sols are quite stable	The sols are less stable.
These are highly hydrated	These are not much hydrated
They are reversible in nature	These are irreversible in nature
The particles in sols do not carry charges.	The particles of these sols carry either positive or negative charge.

	<table><tr><td>They do not show Tyndall effect</td><td>These exhibit Tyndall effect.</td></tr><tr><td>They will not show any action,when placed in an electric field.</td><td>Particles usually migrate towards anode or cathode depending upon their nature of charge.</td></tr></table>		
1b-ii	**Uses of inhibitors :** Inhibitors are organic or inorganic chemicals which are added in small amount to a corrosive solution/medium in order to reduce the corrosive effect of the solution. Usually they form and maintain a protective film on the metal surface and thus act as a barrier for further corrosion. Anodic inhibitors such as sodium or potassium chromates , phosphates and silicates tend to suppress the anodic reaction or metal dissolution. Cathodic inhibitors control the cathodic reaction. Many organic components such as amines, thiourea and mercaptants function as cathodic inhibitors. Cathodic and anodic inhibitors working together are more effective than acting separately.	4	4
1b-iii	**Criteria for selection of MOC in Chemical Industries** Following are the primary criteria for materials selection <u>1.Strength</u>: The material must be sufficiently strong to withstand indefinitely the pressure difference between the inside of the equipment and the exterior. <u>2.Ease of fabrication</u>: ductility, weldability, castability. <u>3.Resistance to mechanical and thermal shock</u>: A sudden blow or a 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. <u>4.Tendency to form sparks</u>:Because leaks do sometimes develop, when a	1 mark each for any 4	4

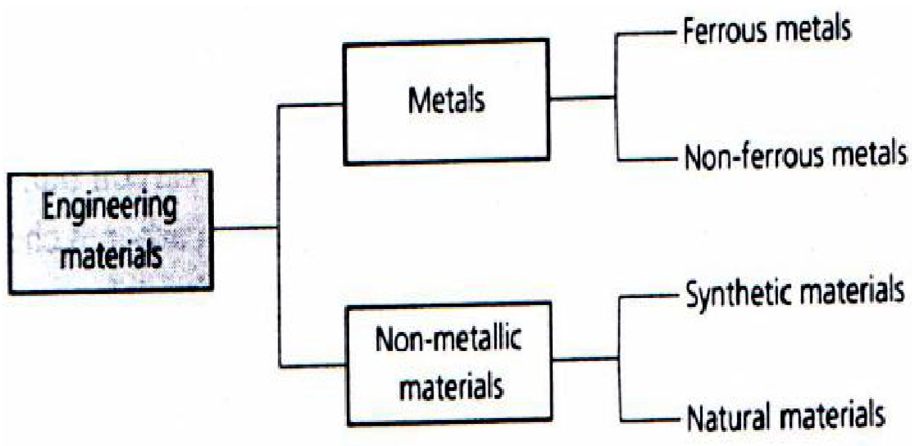
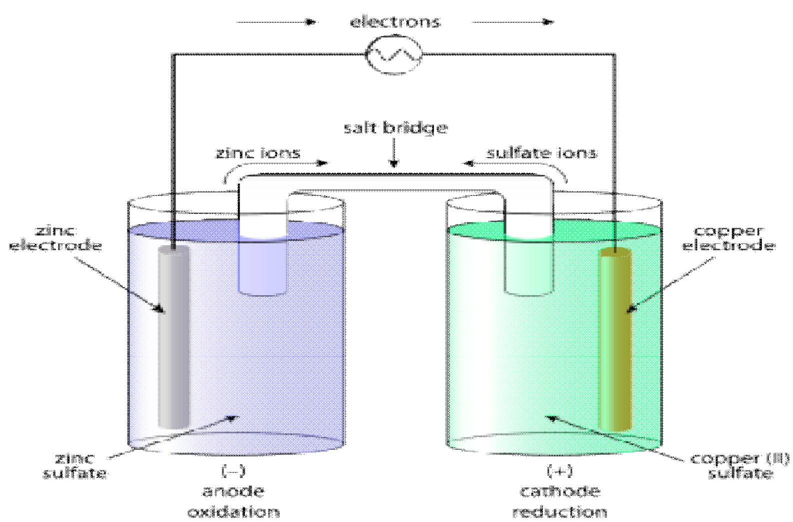
	combustible gas is processed in a unit one must avoid sparks. For this reason, in such a unit constructed of steel, brass tools are supplied to maintenance personnel. 5.Corrosion and chemical resistance: 6. Oxidation resistance The exterior of some materials exposed to air will oxidize, particularly 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.		
2-a	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	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	1 1 1	

2-b	**Electrochemical(Wet corrosion):** It is the corrosion of the metal that occurs in the presence of liquid medium/aqueous environment, through electrochemical reactions. one part behaves as anode and undergoes oxidation and the other part act as a cathode and undergoes reduction. **Mechanism of wet corrosion:** wet corrosion is a two step process. One is anodic or oxidation reaction and the other is cathodic or reduction process. 1) anodic reaction involves dissolution of metal [$M \rightarrow M^{n+} + ne^-$] the anode are absorbed at the cathode. 2) There are different cathodic reactions in which the electrons are consumed depending upon the nature (acidic / basic / neutral) of the corrosion environment. i) Hydrogen evolution type wet corrosion: it occurs in the acidic environment containing no oxygen or very less oxygen. ii) Oxygen absorption type wet corrosion.: it occurs when the environment is alkaline / basic or neutral, and contains more oxygen, OH- ions will be given out.	4	4
2-c	**Degree of Freedom:** **i)** Liquid water for the system c = 1 and p = 1 , according to the phase rule f = c-p+2 , f = 2 for this system has no variance. **ii)** Liquid water and ice C = 1 and p = 2. according to the phase rule f = c-p+2 , f = 1	2 2	4
2-d	Methods of preparation of colloidal solution: 1**) Dispersion methods**: in this method colloiodal size particles are formed by breaking down large macro-sized particles. Those are:	4marks for any one method	4

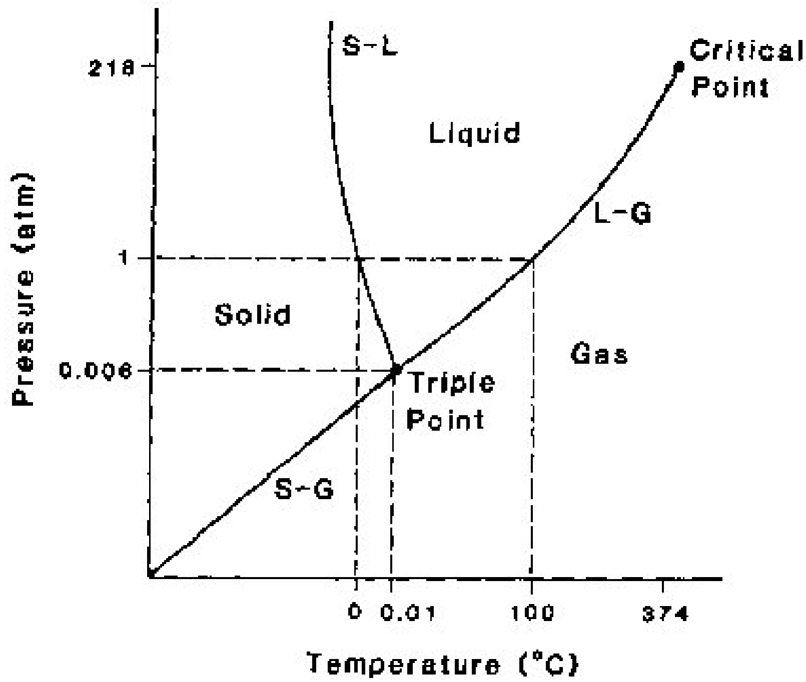
	• **mechanical dispersion method** in this method, coarse colloidal particles are broken down to colloidal size by grinding in a colloidal mill. The mill consists of two steel discs with a small gap between them. The disc rotates at high speed in opposite directions. The substance of which sol is to be prepared is shaken well with the dispersion medium to get a suspension and this suspension is fed to the colloidal mill. In the mill, the particles of the suspension are ground to produce the particles of colloidal size that are dispersed in the liquid resulting in the colloidal solution. • **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. • **Peptization** It is defined as a process of converting a freshly prepared precipitate into colloidal solution by the addition of a suitable electrolyte. The electrolyte added in this process is called as peptizing agent or dispersion agent. For example, if freshly prepared ferric hydroxide[$Fe(OH)_3$] precipitate is treated with a small amount of ferric chloride [$FeCl_3$, electrolyte] solution, a dark reddish brown colloidal solution of $Fe(OH)_3$ is formed. In this case, $FeCl_3$ is a		

	peptizing agent and Fe^{3+} is a common ion. The process of peptization is reverse of coagulation. As the electrolyte is added to a freshly precipitated substance, the particles of the precipitate preferentially absorb one particulare type ions of the electrolyte which give a positive and negative charge and thus they mutually repel each other and get dispersed. This gives particles of colloidal size. For example, $Fe(OH)_3$ absorbs Fe^{3+} ions from $FeCl_3$ and thus gets a positive charge on the surface. Particles carrying the same charge get dispersed, giving smaller size colloidal particles of the type $Fe(OH)_3\,Fe^{3+}$ **2) Aggregation method:** here colloidal size particles are formed 1by aggregation of single molecules. Those are: • **double decomposition** An arsenious sulphide sol is prepared by passing hydrogen sulphide gas through a cold, dilute solution of arsenious oxide and removing excess hydrogen sulphide (electrolyte) by boiling \\ $As_2O_3 + 3H_2S \rightarrow As_2S_3(sol) + 3H_20$ • **reduction** A sol of silver or gold is prepared by treating an aqueous solution of silver nitrate or gold chloride with an organic reducing agent such as tannic acid. $AgNO_3$ + tannic acid -> Ag sol $AuCl_3$ + tannic acid-> Au sol • **Oxidation** A sol of sulphur is prepared by the oxidation of an aqueous solution of hydrogen sulphide with sulphur dioxide. $2H_2S + So_2 \rightarrow 3S$ sol + 2 H_2o		

<table>
<tr><td>2-e</td><td>Classification of engineering materials:

</td><td>4</td><td>4</td></tr>
<tr><td>2-f</td><td>A galvanic cell is an electrochemical cell that uses spontaneous redox reaction to generate electricity. Simple galvanic cell has consist of anode and cathode (two electrodes) salt bridge, two half cells(compartments) and an external circuit with load(light bulb).

</td><td>4</td><td>4</td></tr>
<tr><td>3-a</td><td><table><tr><td>Reversible Process</td><td>Irreversible Process</td></tr><tr><td>1. It takes place in infinite number of infinitesimally small steps and it would take finite time to occur.</td><td>1. It takes place infinite time.</td></tr></table></td><td>1 mark each for any 4</td><td>4</td></tr>
</table>

	2. It is imaginary as it assumes the presence of frictionless and weight less piston.	2. It is real and can be performed actually.		
	3. It is in equilibrium state at all stage of the operation.	It is in equilibrium state only at the initial and final stage of the operation.		
	4. All changes are reversed when the process is carried out in reversible direction.	4. After this type of process has occurred all changes do not return to the initial stage by themselves.		
	5. It is extremely slow.	5. It proceeds at measureable speed.		
	6. Work done by a reversible process is greater than the corresponding irreversible process.	6. Work done by a irreversible process is smaller than the corresponding reversible process.		
3-b	**PHYSICAL ADSORPTION**	**CHEMISORPTIONS**	1 mark each any 4	4
	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 kJ mol^{-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.		
3-c	Glass Lining Properties Glass-lined steel equipment features unique characteristics that make it mandatory for use in processes when service conditions are particularly dif ficult. This is the case for applications involving products that exceed the		2	4

	resistance limitations for corrosion, abra-sion mechanicaland thermalshocks. Chemical and pharmaceutical companies are continually extend-ing the limits of their processes in order to increase productivity or succeed in new developments, calling for higher temperatures, lower temperatures, higher pressures, and higher concentrations. The capability to extend standard limitations is possible only if the equipment in use can withstand these progressive operating requirements Purpose : for storing & transport of i)HCl ii)Water iii)Steam iv)NaOH v)acids storage	2	
3-d	W=nRTln(V2/V1) W=1728.84 J Isothemal process ΔU =0 ΔU =Q-W Q=W Q=1728.84 J As the process is isothermal ΔH =0	1 1 1 1	4

3-e		4	4
3-f	i) PVC: 1) It is also used for bottles, other non-food packaging, and cards (such as bank or membership cards). 2) it is also used in plumbing, electrical cable insulation, imitation leather, signage, inflatable products, and many applications where it replaces rubber.	2	4
	ii) teflon: 1) non stick coatings. 2) gaseous exchange membranes. 3) used as grafts in Bio medical application. 4) used in manfacture of Stopcocks,glass fibres,transformers,plumbing thread tape,etc...used in manfacture of computer mice foot,solid fuel	2	

	rocket propellents,cells used in spectrometer,containers,magnetic stirrers etc...it is also used for making non stick cookwares		
4-a	i)Phase: A **Phase** is a component part of the system that is immiscible with the other parts (e.g. solid, liquid, or gas); a phase may of course contain several chemical constituents, which may or may not be shared with other phases. The number of phases is represented in the relation by **P**. ii)Component: The **Chemical Constituents** are simply the distinct compounds (or elements) involved in the equations of the system. (If some of the system constituents remain in equilibrium with each other whatever the state of the system, they should be counted as a single constituent.) The number of these is represented as **C**. iii) Degrees of freedom The **Degrees of Freedom** [**F**] is the number of independent intensive variables (i.e. those that are independent of the quantity of material present) that need to be specified in value to fully determine the state of the system. Typical such variables might be temperature, pressure, or concentration	1 1 2	4
4-b	1. the protective layer has to be pore - free; 2. it must adhere firmly to the base material; 3. it must be resistant to external mechanical stress; 4. it must possess a certain ductility; and 5. it must be corrosion resistant.	1 mark each for any 4	4
4-c	Statement: The Second Law of Thermodynamics states that the state of entropy of the	1	4

	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: $\Delta Suniv=\Delta Ssys+\Delta Ssurr=qsysT+qsurrT$	1	
	In an isothermal reversible expansion, the heat q absorbed by the system from the surroundings is $qrev=nRT\ln V2V1$	1	
	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 $\Delta Suniv=nRT\ln V2V1T+-nRT\ln V2V1T=0$		
	If the process is irreversible however, the entropy change is $\Delta Suniv=nRT\ln V2V1T>0$		
	If we put the two equations for $\Delta Suniv$together for both types of processes, we are left with the second law of thermodynamics, $\Delta Suniv=\Delta Ssys+\Delta Ssurr\geq 0$		
	where $\Delta Suniv$ 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.	1	
	The second law of thermodynamics can also be stated that "all **spontaneous**		

	processes produce an **increase** in the entropy of the universe".		
4.d	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. **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	1 1	4

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

The above equation is known as Freundlich adsorption equation.

Plotting of Freundlich Adsorption Isotherm

As per Freundlich adsorption equation

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

1

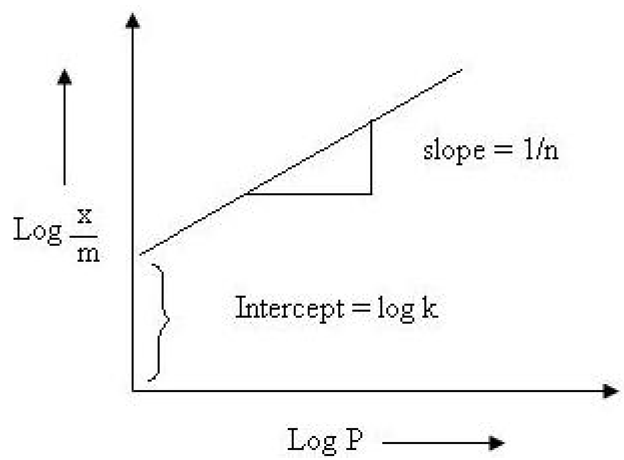
Taking log both sides of equation, we get,

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

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

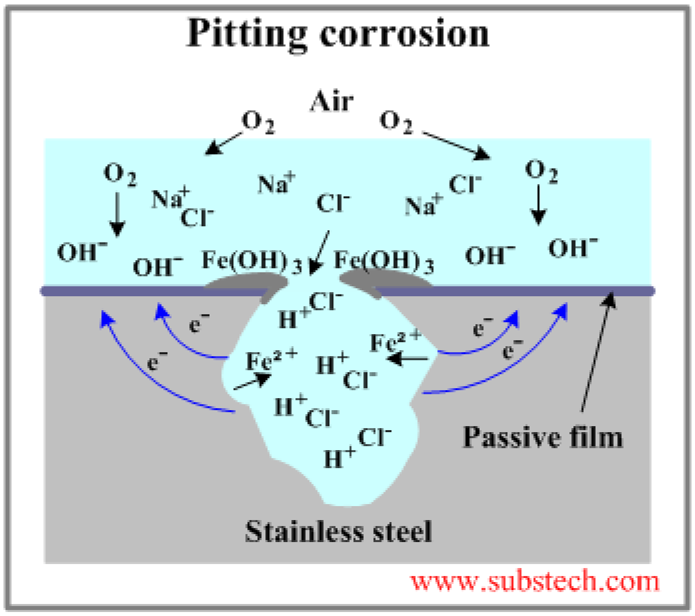


log(x/m) vs. log p graph

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.		
4-e	***Pitting Corrosion*** Pitting corrosion is a localized form of corrosion by which cavities or "holes" a the material. Pitting is considered to be more dangerous than uniform corrosion d it is more difficult to detect, predict and design against. Corrosion products ofter A small, narrow pit with minimal overall metal loss can lead to the failu engineering system. Pitting corrosion, which, for example, is almost a common all types of localized corrosion attack, may assume different shapes. Pitting produce pits with their mouth open (uncovered) or covered with a semi-permeab corrosion products. Pits can be either hemispherical or cup-shaped Pitting corrosion is a localized form of corrosion by which cavities or "holes" are produced in the material. Pitting is considered to be more dangerous than uniform corrosion damage because it is more difficult to detect, predict and design against. Corrosion products often cover the pits. A small, narrow pit with minimal overall metal loss can lead to the failure of an entire engineering system. Pitting corrosion, which, for example, is almost a common denominator of all types of localized corrosion attack, may assume different shapes. Pitting corrosion can produce pits with their mouth open (uncovered) or covered with a semi-permeable membrane of corrosion products. Pits can be either hemispherical or cup-shaped Pitting is initiated by: a. Localized chemical or mechanical damage to the protective oxide film; water chemistry factors which can cause breakdown of a	1 1 1 1	4

	passive film are acidity, low dissolved oxygen concentrations (which tend to render a protective oxide film less stable) and high concentrations of chloride (as in seawater) b. Localized damage to, or poor application of, a protective coating c. The presence of non-uniformities in the metal structure of the component, e.g. nonmetallicinclusions.  Theoretically, a local cell that leads to the initiation of a pit can be caused by an abnormal anodic site surrounded by normal surface which acts as a cathode, or by the presence of an abnormal cathodic site surrounded by a normal surface in which a pit will have disappeared due to corrosion.		
4-f	i)H2SO4: Store in a metallic or coated fiberboard drum using a strong polyethylene inner package ii)CH3COOH:	1 1	4

	Storage tanks may be constructed of aluminium or stainless steel. iii)C2H5OH: Tanks should be double-walled and must be either steel, fiberglass jacketed steel, or UL-listed fiberglass iv)Caustic Soda: Stainless steel	 1 1	
5-a	**Applications of adsorption are as follows (any four)** 1. In production high vacuum : In order to remove traces of air from partially evacuated container, it is connected to a small bulb filled with activated charcoal or 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. This technique is used in Dewar's flask used for storing liquid air. 2. 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. 3. In removing coloring matter from solutions : Animal charcoal removes colors of solution by adsorbing impurities. Animal charcoal is used as a decoloriser in the manufacture of cane sugar. 4. In dehumidification: Silica gel removes moisture (water vapors) present in the air by adsorption (silica gel adsorbs moisture). Hence silica gel is used for dehumidification of air in the storage facility of delicate electronic instruments. 5. In Heterogeneous catalysis: Solid catalyzed gas phase reactions proceeds through the adsorption of gaseous reactants on the surface of a solid catalyst. 6. in chromatographic analysis : with the help of a chromatographic technique it is possible to separate and analyze mixture containing small quantities of organic substances. The components of a mixture have different adsorption	1 mark each Any 4	4

	tendencies. Usually silica gel or alumina is used as adsorbent.		
5-b	**Caustic embrittlement** is the phenomena in which the material of boiler becomes brittle due to local accumulation/deposition of sodium hydroxide at high temperatures (200-250 deg C) Caustic embrittlement occurs at the stressed parts of the boiler such as cracks, bends, rivets and joints. The accumulated sodium hydroxide attacks the material of the boiler and dissolves iron as sodium ferrite. Sodium carbonate is used for softening water by lime soda process. Residual sodium carbonate left behind in the water undergoes hydrolysis to produce sodium hydroxide at high temperatures and pressures. Caustic embrittlement may cause failure of boiler. Caustic embrittlement can be prevented by reducing pH, using sodium sulphate as a softening reagent and by increasing the passivity of mild steel.	4	4

5-c i) **open and closed system :** 4

Open system	Closed system
In which exchange of energy or matter takes place across the boundary with its surroundings	In which exchange of energy but not matter takes place across the boundary with its surroundings
Boundary will be open	Boundary will be closed.

2

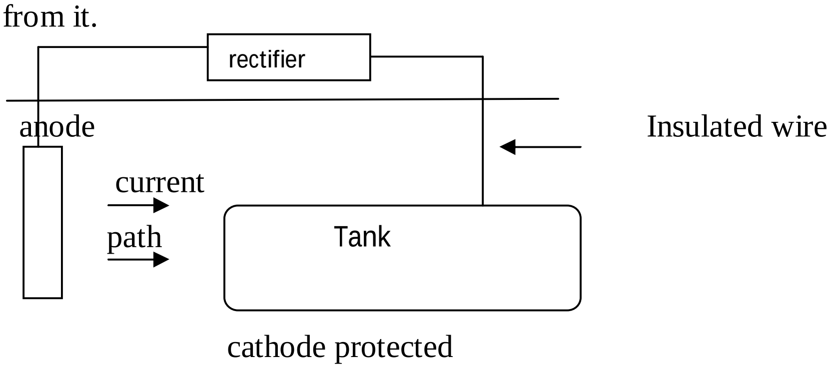
Isobaric and isochoric process:

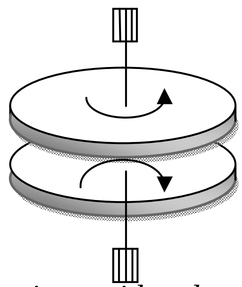
Isobaric process	Isochoric process
1. Process is carried out at constant pressure	Process is carried out at constant volume
2. Change in pressure ΔP is zero	Change in volume ΔV is zero
3. Pressure remains constant	Volume remains constant
4. e.g. reaction carried out in open vessel	e.g. gas phase reaction carried out in sealed vessel

2

5-d	**Properties of carbon steel** are as follows, **(any four)** i) It is cheap ii) It has good tensile strength and ductility. iii) It is malleable iv) It can be easily rolled, forged, bent and drawn v) It is easily machined and weldable vi) It is relatively hard and easily annealed vii) It is durable	1 mark each any 4	4
5-e	(i) for volume constant $\Delta S = nC_v \ln T_2/T_1$, since value of Cv is not given any assumed value should be given mark (ii) for constant pressure $\Delta S = nC_p \ln T_2/T_1$, since value of Cp is not given any assumed value should be given mark		4
5-f	Let P be the equilibrium pressure of the gas and θ be the fraction of surface covered by the gas molecules then (1-θ) is the fraction of the uncovered surface(i.e. available surface). The rate of adsorption is proportional to P and (1-θ), and the rate of desorption is proportional to θ (covered surface). Therefore rate of adsorption= $k_1 (1-\theta)P$ Rate of desorption= $k_2 \theta$ k1 and k2 are the rates constants for adsorption and desorption respectively. At equilibrium the rates of these two opposing processes are equal. Therefore, Rate of adsorption=Rate of desorption $k_1 (1-\theta)P = k_2 \theta$ $k_1 P - k_1 \theta P = k_2 \theta$ $k_1 P = \theta (k_1 P - k_2)$		4

	$$\theta = \frac{k1\,P}{k1\,P + k2}$$ Dividing both the numerator and denominator on the RHS of the above equation by k_2 gives $$\theta = \frac{(\frac{k1}{k2})\,P}{\left(\frac{k1}{k2}\right)P + \frac{k2}{k2}}$$ $$\theta = \frac{(\frac{k1}{k2})P}{\left(\frac{k1}{k2}\right)P+1}$$ Putting $\frac{k1}{k2}$= b, it becomes, $$\theta = \frac{bP}{bP+1} \qquad \ldots\ldots(1)$$ If w is the amount of gas adsorbed at any instant and w_0 is the maximum possible amount of the gas that can be adsorbed, then w/ w_0 represents the fraction of the surface covered. Therefore, $$\theta = \frac{w}{w_0}$$ With this equation (1) becomes, $$\theta = \frac{w}{w_0} = \frac{bP}{bP+1}$$ This can be written as $$\frac{w/m}{w_0/m} = \frac{bP}{bP+1}$$ $$\frac{w}{m} = \frac{(w_0\|m)bP}{1+bP}$$ $$\frac{w}{m} = \frac{aP}{1+bP}$$ where a= (w_0/m) b …….(2) For a given experiment w_0/m is constant. Since b is constant the product		

	$(w_0/m)b$ is constant. Equation 2 is called Langmuir adsorption isotherm.		
6-a	**Impressed current method:** 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 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.  	4	4
6-b	**Mechanical dispersion method -** i) In this method coarse particles are broken down to colloidal size by grinding in a colloidal mill. ii) The mill consists of two steel disks with a small gap between them. iii) The disk rotates at high speed in opposite direction. iv) The substance of which sol is to be prepared is shaken well with the dispersion medium to get a suspension and this suspension is fed to the colloidal mill. v) In the mill particles of the suspension are ground to produce the particles of		4

	colloidal size that are dispersed in the liquid resulting in colloidal solution. vi) Printing inks and colloidal graphite are prepared by this technique.  *Any one method given by student is considered.*		
6-c	**i) Isothermal process** Ans.: A process which carried out at a constant temperature is called as an isothermal process. ii**) Adiabatic process** Ans.: A system which is thermally insulated from its surroundings is called adiabatic process. **iii) Cyclic process** Ans.: A process or a series of processes, undergone by a system as a result of which the system is returned/restored exactly to its initial/original state is called as a cyclic process **iv) Internal energy** Ans.: Internal energy of a substance is the energy possessed by the molecules constituting the substance and not the energy possessed by the substance as a whole due to its macroscopic motion or position	1 1 1 1	4

6-d	**Third law of thermodynamics**: Third law of thermodynamics stats that at absolute zero temperature the entropy of pure crystalline substance is zero. $\Delta S = 0$ at T=0 (T is absolute temperature) **Zeroth law of thermodynamics**: it states that if two bodies are separately in thermal equilibrium with a third body, then there is in thermal equilibrium with each other. Let us assume there are three bodies A, B and C. then for thermal equilibrium If $A \cong B$ and $B \cong C$ Then $A \cong C$	1 1 1 1	4
6-e	**Importance of plastic lining is as follows (any four)** i) It gives underlying structure protection against chemical attack ii) It prevents contamination of the materials being processed iii) It minimizes the effect of abrasion iv) increases ease of cleaning v) it provides high mechanical strength vi) strength of the base metal is coupled with corrosion resistance of the plastic lining vii) Life of the base metal in increased with plastic lining viii) Chemicals which are corrosive to metals can be stored or processed in vessels lined with plastic.	1 mark each	4
6-f	**i) Uniform corrosion**	2	4

	Ans.: i) Aqueous corrosion of iron in H_2SO_4 ii) Atmospheric corrosion of steel structure **ii) Oxidation corrosion** Ans.: i) Rusting of iron when exposed to atmosphere ii) Oxygen in boiler feed water can attack boiler metal and cause oxidation corrosion	2	