SUMMER-14 EXAMINATION

Model Answer

Subject code : (17423)

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.

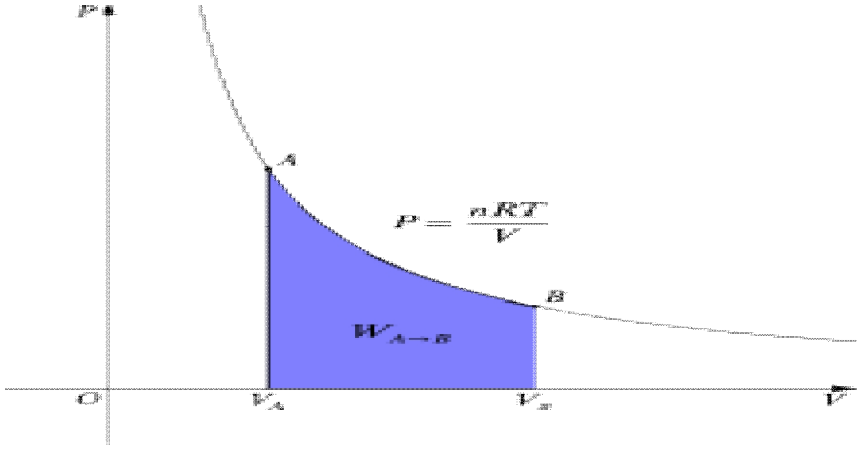
Q No.	Answer	marks	Total marks
1a-i	**Isobaric:** A process which is carried out at a constant pressure is called isobaric process. **Isochoric:** A process which is carried out at a constant volume is called an isochoric process.	1 1	2
1a-ii	**Lyophilic sol**: Colloidal systems in which the dispersed phase has a great affinity for the dispersion medium are called lyophilic solutions. **Lyophobic sols**: colloidal systems in which the dispersed phase has no affinity for the dispersion medium are called lyophobic sols.	1	2
1a-iii	**Electrochemical series:** the electrode potential of all metals is measured using standard hydrogen electrode. When metals are arranged in order to their standard electrode potentials, a series obtained is called an electrochemical series.	1	2
1a-iv	**Degree of freedom**: it is the number of degree of a system is the number of independent intensive variables such as temperature, pressure and composition that must be specified so that the remaining variables are fixed automatically and state of the system is completely defined. which is expressed in phase rule as a , F=C-P+2.	2	2
1a-v	**The second law of thermodynamics**: All the statements are equivalent • Heat or in general any type of energy flows from a higher level to a lower level. • When two bodies are at different temperatures, heat flows from a hot body to a relatively cold body.	Any of the one statment carry 2 marks	2

	• All natural or spontaneous processes are not thermodynamically reversible. • Complete conversion of heat into work is impossible without producing some changes in the system or its surroundings. • Its impossible to transfer heat from a cold body to a hot body without the aid of external work.		
1a-vi	Elements used for alloying iron are: Carbon Manganese Chromium Nickel Molybdenum Titanium Phosphorus Sulphur Selenium Niobium Nitrogen Silicon Cobalt Tantalum Copper	Any 8 elements	2
1a-vii	**Dry corrosion:** dry corrosion occurs by direct chemical attack/action of atmospheric gases like oxygen, halogen sulphide etc. In a dry environment on the surface of a metal.	2	2
1b-i	**Aggregation method of preparing of colloidal solution:**		4

	The methods of preparing sols involve chemical reactions, such as double decomposition, reduction, etc, by which the atoms or molecules of the dispersed phase appearing first, coalesce or aggregate to form colloidal particles. **1. 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. $Ar_2O_3 + 3H_2S \rightarrow Ar_2S_3 + 3H_2O$ **2. 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 **3. 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 $+2H_2O$	Any 1 method carry 4 marks	
1b-ii	**Caustic embrittlement**: it is the phenomenon in which the material of a boiler becomes brittle due to local accumulation/ decomposition of sodium hydroxide at high temperature (200-250^{0}C).its occurs at the stressed parts of the boiler such as cracks,bends,rivets and joints. The accumulated sodium hydroxide attack the material of the boiler and dissolves iron as sodium ferrite. Sodium carbonate is used for the softening water by lime soda process. residual sodium carbonate left behind in the water undergoes hydrolysis to produce	4	4

	sodium hydroxide at high temperatures and pressures. Effects: it may cause failure of boilers. it can be prevented by reducing pH,using sodium sulphate as a softening reagents and by increasing passivity of mild steel.		
1b-iii	**Properties of Teflon**: 1. It is hydrophobic. 2. It is a fluorocarbon solid. 3. It is a white solid at room temperature. 4. It has a density of 2200 kg/m^3 5. It is tough, non- sticking and good insulating material. 6. It can be easily machined, punched or drilled. 7. Excellent corrosion resistance. **Properties of PVC** : 1. It is a white brittle solid material. 2. It is fire retardant and extinguishable. 3. It has good resistance to weather. 4. It has good resistance to acids and alkalies and inorganic chemicals. 5. It is non-flammable and low cost material. 6. It has greater stiffness and rigidity than polyethylene.	½ marks for any 4 ½ marks for any 4	4
2-a	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	4	4

Calculation of work



The dark area represents "work" for this isothermal changeIn thermodynamics, the work involved when a gas changes from state *A* to state *B* is simply

$$W_{A \to B} = -\int_{V_A}^{V_B} p\,dV$$

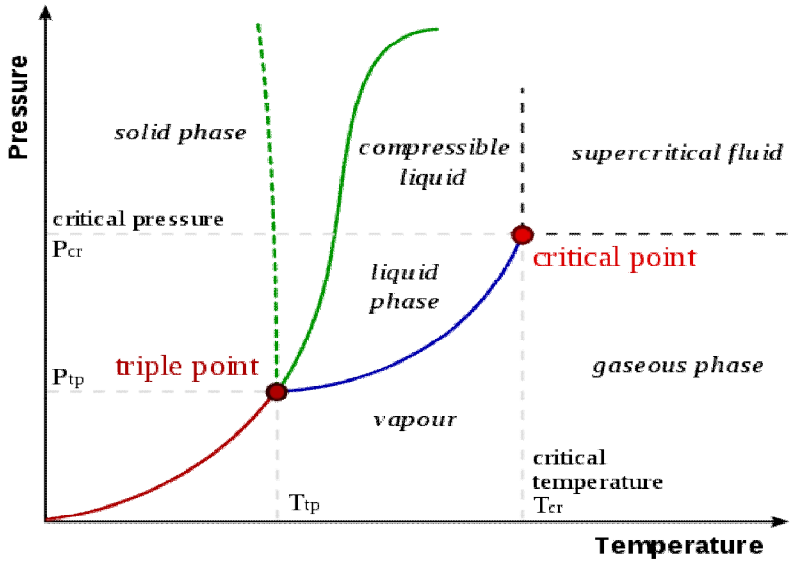
For an isothermal, reversible process, this integral equals the area under the relevant pressure-volume isotherm, and is indicated in purple in the figure (at the bottom right-hand of the page) for an ideal gas. Again, $p = nRT / V$ applies and with *T* being constant (as this is an isothermal process), we have:

$$W_{A \to B} = -\int_{V_A}^{V_B} p\,dV = -\int_{V_A}^{V_B} \frac{nRT}{V}\,dV = -nRT\int_{V_A}^{V_B} \frac{1}{V}\,dV = -nRT \ln \frac{V_B}{V_A}$$

By convention, work is defined as the work the system does on its environment. If, for example, the system expands by a piston moving in the direction of force applied by the internal pressure of a gas, then the work is counted as positive, and as this work is done by using internal energy of the system, the result is that

	the internal energy decreases. Conversely, if the environment does work on the system so that its internal energy increases, the work is counted as negative.It is also worth noting that, for many systems, if the temperature is held constant, the internal energy of the system also is constant, and so $\Delta U = 0$. From First Law of Thermodynamics, $\Delta U = Q - W$, so it follows that $Q = W$ for this same isothermal process.When no heat flows into or out of the gas because its container is at the same temperature, then there is no work done. Thus, work=0 which means external pressure on any moving surface is zero. This is called free expansion.		

2-b	Galavanic series of metals: The **galvanic series** (or **electro potential 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 Metals Largest, corrosive part, positive 1 - Magnesium 2 - Zinc 3 - Cadmium 4 - Aluminum 5 - Steel 6 - Iron 7 - Stainless-Steel 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	2marks 2marks	4
			4

2-c	 • **Triple point** – the point on a phase diagram at which the three states of matter: gas, liquid, and solid coexist • **Critical point** – the point on a phase diagram at which the substance is indistinguishable between liquid and gaseous states • **Fusion(melting) (or freezing) curve** – the curve on a phase diagram which represents the transition between liquid and solid states • **Vaporization (or condensation) curve** – the curve on a phase diagram which represents the transition between gaseous and liquid states • **Sublimation (or deposition) curve** – the curve on a phase diagram which represents the transition between gaseous and solid states Phase diagrams plot pressure (typically in atmospheres) versus temperature (typically in degrees Celsius or Kelvin). The labels on the graph represent the stable states of a system in equilibrium. The lines represent the combinations of pressures and temperatures at which two phases can exist in equilibrium.	4	
2-d	**Differences between lyobhic and lyophilic solution:**	Any 4	4

		lyophilic	**lyophobic**	points,each carry 1 mark	
		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.		
		They do not show Tyndall effect	These exhibit Tyndall effect.		
		They will not show any action,when placed in an electric field.	Particles usually migrate towards anode or cathode depending upon their nature of charge.		
2-e	**Selection criteria for material of construction on property of chemical:**			Any 4 types	4

		each carry 1 mark	

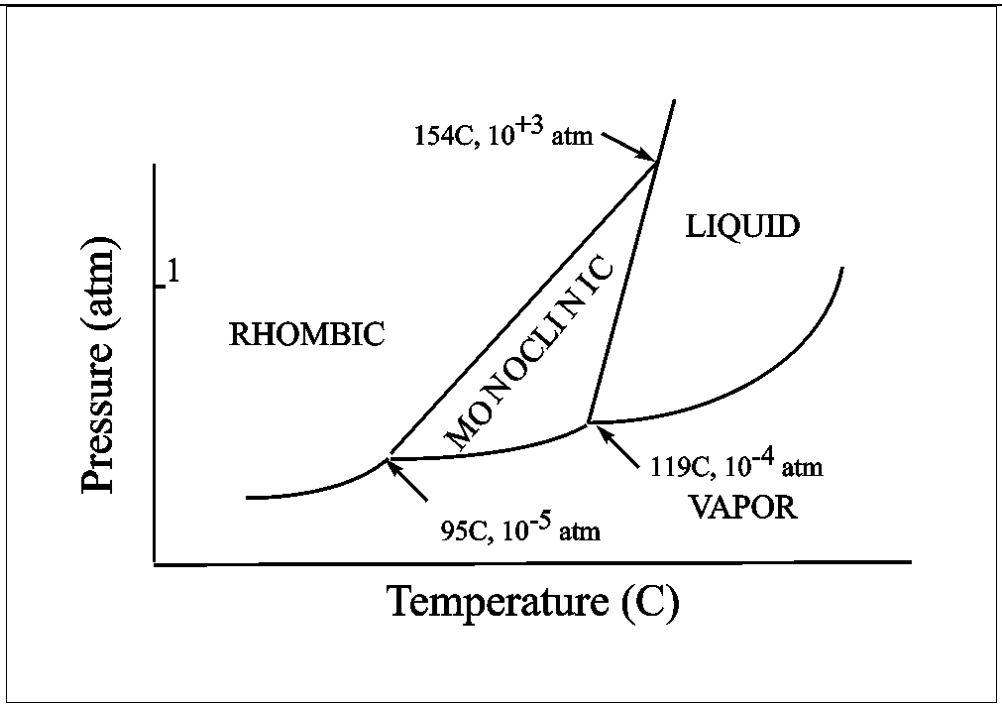
Mild steel	Used for storage of oleum,methanol,acetone,benzene,toluene,ether etc
Nickel stainless steel	Hot oleum
Lead	Hot sulphuric acid
Rubber lined mild steel	Dilute sulphuric acid
SS-316,SS-304	Mixed acid, soda ash, sodium carbonate
Nickel	Concentrated alkalies
Aluminium	Fuming nitric acid,organic aliphatic acids
Plypropylene,teflon	NaCl solution

2-f	**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

3-a	Reversible Process	Irreversible Process	1 mark each for any four	4
	1. It takes place in infinite number of infinitesimally small steps and it would take finite time to occur.	1. It takes place infinite time.		
	2. It is imaginary as it assumes the presence	2. It is real and can be performed actually.		

	of frictionless and weight less piston.			
	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	**Assumptions of Langmuir Isotherm** Langmuir proposed his theory by making following assumptions. 1. Fixed number of vacant or adsorption sites are available on the surface of solid. 2. All the vacant sites are of equal size and shape on the surface of adsorbent. 3. Each site can hold maximum of one gaseous molecule and a constant amount of heat energy is released during this process. 4. Dynamic equilibrium exists between adsorbed gaseous molecules and the free gaseous molecules. $A(g) + B(S) \underset{\text{desorption}}{\overset{\text{Adsorption}}{\rightleftharpoons}} AB$ Where A (g) is unadsorbed gaseous molecule, B(s) is unoccupied metal surface and AB is Adsorbed gaseous molecule. 5. Adsorption is monolayer or unilayer.		4	4

3-c	***Rubber Lining*** Rubber Lining is the skilled application and bonding of rubber sheet to specially prepared surfaces. The rubber can be applied as either unvulcanised material which is then vulcanised and hot bonded – usually in a steam autoclave; or as pre vulcanised material which is cold bonded using two part adhesives. The fully bonded lining provides a durable and resilient protective rubber coating that will withstand very aggressive process conditions and applications. Rubber Linings and Coatings can be from 2mm to 50mm thick depending on the application, and can be bonded to mild steel, stainless steel, cast iron and aluminium. **Purpose:** 1. The principal benefits of rubber lining are its excellent resistance to corrosive and abrasive chemicals and materials, e.g. acids, alkalis, salt water, slurries, sand, shotblast media, crushed rock etc. 2. In addition rubber linings provide other benefits including noise and vibration reduction, electrical and thermal insulation and product protection. 3. It is used to protect Chemical process tanks, agitators, mixers, pumps, fans,Water treatment columns,Plating tanks (nickel, copper, cadmium) Pipe and fittings,Pickling tank etc.	2 2	4
3-d	*W=-nR ln(P1/P2)* W=-5900 J For isothermal expansion W=q=5900J	2	4

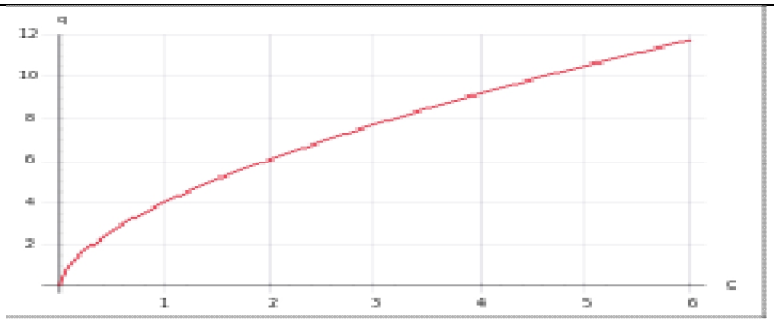
	U=q+w=11800j	2	
3-e		4	4
3-f	The various industrial applications in which **PVC compounds** are used include 1. Petrol tubes, 2. profiles, 3. co extrusion strap, 4. hoses for fuel & oils, 5. gaskets, 6. sleeves, 7. door & window profiles and sliding, 8. H-band, 9. fitting, 10. lip seals, 11. co-extrusion spiral hoses and all tailor made applications, etc.	1 mark each for any two	4

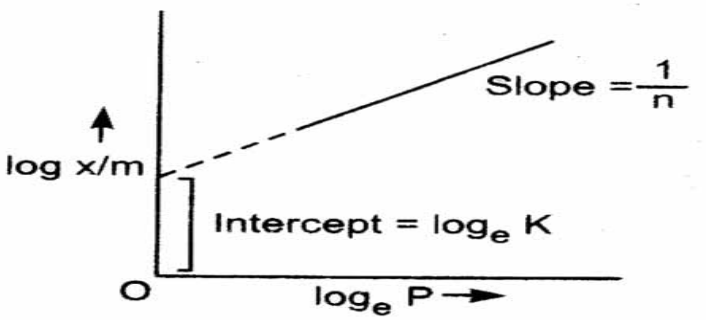
	Application of polypropylene: 1. for pumps 2. pipes 3. as scrubber 4.used for tanks 5.reaction vessels	1 mark each for any two	
4-a	**F = C - P + 2.** The **Degrees of Freedom** [**F**] is the number of independent intensive variables (i.e. those that are independent of the quantity of material present) that need to be specified in value to fully determine the state of the system. Typical such variables might be temperature, pressure, or concentration. 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**. 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**.	1 1 1 1	4
4-b	1. Forms a Protective Barrier 2. Enhances Appearance 3. Reduces Friction 4. Conducts Electricity	½ mark each for any 8	4

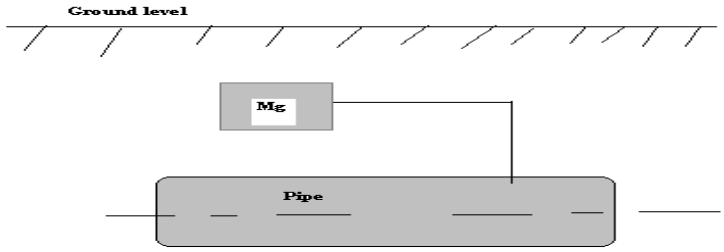
<table>
<tr><td></td><td>5. Absorbs Excess Hydrogen
6. Prevents Formation of Whiskers
7. Resists Heat
8. Increases Hardness
9. Absorbs Light and Energy
10. Promotes Adhesion
11. Increases Thickness
12. Prevents Tarnishing</td><td></td><td></td></tr>
<tr><td>4-c</td><td><u>Zeroth law of thermodynamics</u>:
If two systems are in <u>thermal equilibrium</u> respectively with a third system, they must be in thermal equilibrium with each other. This law helps define the notion of <u>temperature</u>.
Third law of thermodynamics:
The entropy of a system approaches a constant value as the temperature approaches absolute zero. With the exception of glasses the entropy of a system at absolute zero is typically close to zero, and is equal to the log of the multiplicity of the quantum ground state.</td><td>2

2</td><td>4</td></tr>
<tr><td>4.d</td><td><table><tr><th>PHYSICAL ADSORPTION</th><th>CHEMISORPTIONS</th></tr><tr><td>The forces operating in these are weak vander Waal’s forces.</td><td>The forces operating in these cases are similar to those of a chemical bond.</td></tr><tr><td>The heat of adsorption are low i.e. about 20 – 40 kJ mol^{-1}</td><td>The heat of adsorption are high i.e. about 40 – 400 kJ mol^{-1}</td></tr><tr><td>No compound formation takes place in these cases.</td><td>Surface compounds are formed.</td></tr><tr><td>The process is reversible i.e.</td><td>The process is irreversible. Efforts to</td></tr></table></td><td>1 mark each for any 4</td><td>4</td></tr>
</table>

	desorption of the gas occurs by increasing the temperature or decreasing the pressure.	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.		
4-e	**Effect of temperature on corrosion** 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		1 mark each for any 4	4

	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. 5. In a closed system, where oxygen cannot escape the corrosion rate continues to increase indefinitely with temperature until all the oxygen is consumed.		
4-f	Caustic lye: 1. SS Soda Ash: 1. Polyethylene 2. Woven plastic material + PE Niric acid: 1. Cast iron 2. Stone ware Hydrochoric acid: 1. Rubber line still tank	1 1 1 1	4
5-a	 Example of the Freundlich isotherm, showing the amount adsorbed, q (e.g., in mol/kg), as a function of equilibrium concentration in the solution, c (e.g., in mol/L).	4	4

	The Freundlich Adsorption Isotherm is mathematically expressed as $\frac{x}{m} = Kp^{1/n}$ It is also written as $\log \frac{x}{m} = \log K + \frac{1}{n} \log p$ Or $\frac{x}{m} - Kc^{1/n}$ It is also written as $\log \frac{x}{m} = \log K + \frac{1}{n} \log c$ where x = mass of adsorb ate m = mass of adsorbent p = Equilibrium pressure of adsorbate c = Equilibrium concentration of adsorbate in solution. K and n are constants for a given adsorbate and adsorbent at a particular temperature. At high pressure 1/n = 0, hence extent of adsorption becomes independent of pressure.  		
5-b	**Sacrificial anodic method**: In this method, a more active metal is connected to the metal structure/surface to be protected so that corrosion is concentrated at the more active metal and	2	4

<table>
<tr><td></td><td>thus protecting the metal structure/surface from corrosion. The more active metal is called sacrificial anode. The sacrificial anode is replaced by fresh one, when consumed completely for continued corrosion protection of the metal surface.
 
</td><td>2</td><td></td></tr>
<tr><td>5-c</td><td>Differences:
i) Isothermal process and adiabatic process.
<table><tr><td>Isothermal</td><td>adiabatic</td></tr><tr><td>A process which is carried out at a constant temperature.</td><td>A process is carried out in no heat enters or leaves the system.</td></tr><tr><td></td><td></td></tr></table>ii) open and closed system :
<table><tr><td>Open system</td><td>Closed system</td></tr><tr><td>In which exchange of energy or matter takes place across the boundary with its surroundings</td><td>In which exchange of energy but not matter takes place across the boundary with its surroundings</td></tr><tr><td>Boundary will be open</td><td>Boundary will be closed.</td></tr></table></td><td>2

2</td><td>4</td></tr>
<tr><td>5-d</td><td>Properties of mild steel:
1) It is cheap.</td><td>½ marks for any 8</td><td>4</td></tr>
</table>

	2) it has good tensile strength and ductility 3) It is malleable. 4) it can be easily rolled, forged ,bent and drawn 5) It is durable. 6) it is easily machined and weld able 7) It is relatively hard and easily annealed. 8) It easily rusts. 9) Its corrosion resistance is limited.		
5-e	**Langmuir's adsorption isotherm:** **Derivation:** 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 – θ). Now, Rate of forward direction depends upon two factors: Number of sited available on the surface of adsorbent, (1 – θ) and Pressure, P. Therefore rate of forward reaction is directly proportional to both mentioned factors. Rate of forward reaction $\propto P(1-\theta)$ Rate of adsorption $\propto P(1-\theta)$ Or, Rate of adsorption $= K_a P(1-\theta)$	4	4

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 $\propto \theta$

Or, 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.

$K_aP - K_aP \theta = K_d \theta$

$K_aP = K_aP \theta + K_d \theta$

$K_aP = (K_d + K_aP) \theta$

$$\theta = \frac{K_a P}{K_d + K_a P}$$

Divide numerator and denominator on RHS by K_d, we get

$$\theta = \frac{\frac{K_a}{K_d} P}{\frac{K_d}{K_d} + \frac{K_a}{K_d} P}$$

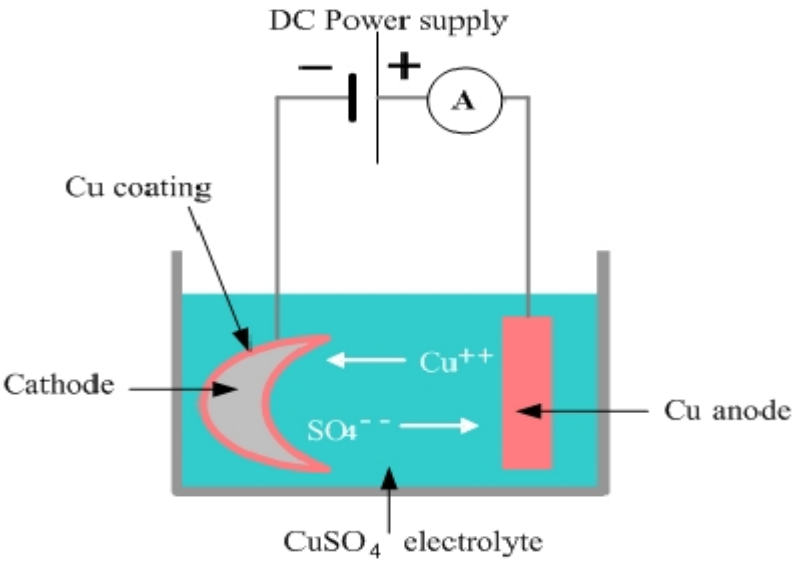
Now put $$K = \frac{K_a}{K_d}$$

in above equation we get $$\theta = \frac{KP}{1 + KP}$$

Langmuir Adsorption Equation

This is known as Langmuir Adsorption Equation.

6-a	**Electroplating:** First, a container is filled with a solution of a salt of the metal that is to form the coating. For example, if copper is to form the coating, the solution will consist of copper sulfate (a salt of copper) mixed with water. This solution is called the electrolytic bath. The object to be plated is immersed in the bath. A metal bar, composed either of the metal that is to form the coating or of a metal that is not affected by the electrolytic bath, is also immersed in the bath. The entire apparatus is called an electrolytic cell. The object to be coated is connected to the negative terminal of an electric battery or other source of direct current, and becomes the cathode (the electrode through which negative charge enters an electrical device). The metal bar is connected to the positive terminal of the electric power source and becomes the anode (the electrode through which negative charge leaves). When electric power is applied, electrolysis of the electrolytic bath occurs. The bath gives up its metal content to the surface of the cathode. This coating forms an alloy with the metal of the cathode, and adheres to the cathode after the cathode has been removed from the bath. As the electroplating process continues, the metal salts in the bath are used up. If the anode is a bar of the coating metal, the bar dissolves in the bath at the same rate that the bath gives up its metal to the cathode. If the anode is made of another metal, salts of the coating metal must be added to the bath as metal becomes deposited on the cathode.	2	4

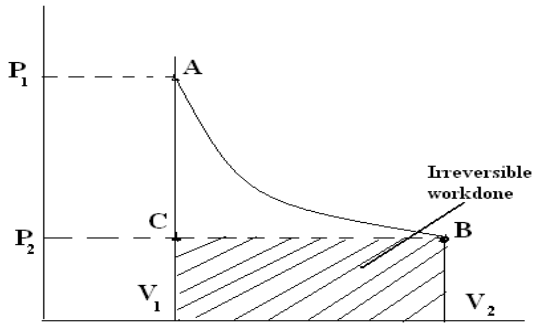
		2	
6-b	**Peptization:** It is defined as a process of converting a freshly prepared precipitate Into colloidal solution (i.e., converting a precipate into colloidal particles) by the addition of a suitable electrolyte (having an ion in common with that of precipitate). The electrolyte added in this process is called as peptizing agent or dispersion agent. As the electrolyte is added to a freshly precipitated substance, the particles of the precipitate preferentially adsorb one particular type ions of the electrolyte which give a positive or negative charge and thus they mutually repel each other and get dispersed. This gives particles of colloidal size. This can be explained with the example of $Fe(OH)_3$ and $FeCl_3$.	4	4

6-c	**Define:** **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. **Isolates system**: a system which can exchange neither matter nor energy through the boundaries with its surroundings is called an isolated system. The combination of a system and its surroundings constitutes an isolated system.	4	4
6-d	**Work done in irreversible isothermal expansion of a gas:** Suppose we have a gas contained in a cylinder piston assembly. In this case, the process of expansion of a gas is to be performed irreversibly, then the expansion is to be carried out instantaneously reducing the external pressure P_{ex} to the final pressure P_2throughout the expansion process. thus the irreversible work done is given by $$W = P_{ex} \int_{V_1}^{V_2} dV$$	4	4

$W=P_2(V_2- V_1)$

In the free expansion of a gas the external pressure is zero,

$$W = P_{ex}\int_{V_1}^{V_2} dV = 0x\int_{V_1}^{V_2} dV = 0$$



6-e	**Glass Lining :** Glass lining is a typical example of fused lining. its general applications are for equipments such as reactors,columns,pipes.etc. There are mainly two types widely used. **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 and emulsifying agent is sprayed like paint on the metal surface. the coat is air dried. the vessel is then transferred to a furnace and fired at temperatures that effect fusion of glass particles. the vessel is then transferred to a cooling oven and allowed to cool. **2) Hot dust process**: After cleaning the metal surface, ground coat is applied in a manner similar to that adopted in the wet spray process. After firing is completed, the component is removed from the furnace and dry powder cover coat enamel is dusted over its surface.	2 2	4
6-f	**Passivity of metals:** Metals that are normally prone to corrosion will sometimes exhibit passivity to corrosion. Passivity is caused by the formation of a stable , non porous and self healing film of metal oxide on the surface of metal. the oxide film formed by corrosion on a clean metal surface. it acts as a barrier separating the metal surface and the environment and thus prevent the metal from further corrosion in the given environment.	4	4