



SUMMER-17 EXAMINATION
Model Answer

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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.

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Q No.	Answer	Marking scheme
1	Attempt any five	20
1.a	<p>The Second Law of Thermodynamics states that the state of entropy of the entire universe, as an isolated system, will always increase over time The entropy change of the surroundings and the entropy change of the system itself. Given the entropy change of the universe is equivalent to the sums of the changes in entropy of the system and surroundings:</p> $\Delta S_{univ} = \Delta S_{sys} + \Delta S_{surr} = q_{sys}/T + q_{surr}/T$ <p>Third law of thermodynamics: Third law of thermodynamics states that at absolute zero temperature the entropy of pure crystalline substance is zero.</p> <p>$\Delta S = 0$ at $T=0$ (T is absolute temperature)</p>	2
1.b	<p>Langmuir's adsorption isotherm:</p> <p>Derivation:</p> <p>Langmuir Equation which depicts a relationship between the number of active sites of the surface undergoing adsorption (i.e. extent of adsorption) and pressure. To derive Langmuir Equation and new parameter ' θ ' is introduced. Let θ the number of sites of the surface which are covered with gaseous molecules. Therefore, the fraction of surface which are unoccupied by gaseous molecules will be $(1 - \theta)$.</p> <p>Now, Rate of forward direction depends upon two factors: Number of sites available on the surface of adsorbent, $(1 - \theta)$ and Pressure, P. Therefore rate of forward reaction is directly proportional to both mentioned factors.</p>	4



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Rate of forward reaction $\propto P(1 - \theta)$

Rate of adsorption $\propto P(1 - \theta)$

Or, Rate of adsorption = $K_a P(1 - \theta)$

Similarly, Rate of backward reaction or Rate of Desorption depends upon number of sites occupied by the gaseous molecules on the surface of adsorbent.

Rate of desorption $\propto \theta$

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 .

$$K_a P - K_a P \theta = K_d \theta$$

$$K_a P = K_a P \theta + K_d \theta$$

$$K_a P = (K_d + K_a P) \theta$$

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

Divide numerator and denominator on RHS by K_d , we get

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

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

Now put

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

in above equation we get

Langmuir Adsorption Equation

This is known as Langmuir Adsorption Equation.

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1.c	<p>Factors affecting rate of corrosion:</p> <p>the factors that affect the rate of corrosion are:</p> <ul style="list-style-type: none"> • Nature of the metal • Nature of environment. <p>1) Nature of metal:</p> <ol style="list-style-type: none"> a. purity of metal b. surface area of metal c. relative area of cathodic or anodic parts d. position in the galvanic series e. nature of the oxide film f. solubility of the corrosion product g. physical state of the metal h. Volatility of the corrosion product. <p>2) Nature of the environment:</p> <ol style="list-style-type: none"> a. temperature of the environment b. pH of the environment c. presence of impurities in the environment d. amount of oxygen present in the environment e. nature of anions and cations present in the environment f. Presence of suspended particles in the environment. g. humidity of environment 	2
1.d	<p>One component system:</p> <p>For pure substances $C = 1$ so that $F = 3 - P$. In a single phase ($P = 1$) condition of a pure component system, two variables ($F = 2$), such as temperature and pressure, can be chosen independently to be any pair of values consistent with the phase.</p>	4



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	<p>However, if the temperature and pressure combination ranges to a point where the pure component undergoes a separation into two phases ($P = 2$), F decreases from 2 to 1. When the system enters the two-phase region, it becomes no longer possible to independently control temperature and pressure. Even for a pure substance, it is possible that three phases, such as solid, liquid and vapor, can exist together in equilibrium ($P = 3$). If there is only one component, there are no degrees of freedom ($F = 0$) when there are three phases. Therefore, in a single-component system, this three-phase mixture can only exist at a single temperature and pressure, which is known as a triple point.</p> <p>Two component system:</p> <p>For binary mixtures of two chemically independent components, $C = 2$ so that $F = 4 - P$. In addition to temperature and pressure, the other degree of freedom is the composition of each phase, often expressed as mole fraction or mass fraction of one component.</p> <p>As an example, consider the system of two completely miscible liquids such as toluene and benzene, in equilibrium with their vapors.</p>	
1.e	<p>Examples of Commonly used Material of Constructions</p> <ol style="list-style-type: none">1) Cast Iron Gray – Gray Cast Iron, White cast Iron2) Mild Steel3) Stainless Steel- SS-304,4) Stainless Steel- SS-316,5) Stainless Steel- SS-3046) Aluminum and its alloys7) Plastics- PVC,8) PTFE-	<p>½ mark each for any 8</p>



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	9) Teflon, 10) PP,HDPE	
1.f	<p>Isochoric process Process is carried out at constant volume Change in volume ΔV is zero Volume remains constant</p> <p>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.</p> <p>Isobaric process: An isobaric process is a thermodynamic process in which the pressure stays constant: $\Delta P = 0$.</p> <p>Adiabatic process Ans.: A system which is thermally insulated from its surroundings is called adiabatic process.</p> <p>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</p>	1 mark each for any 4
1g	<p>1) Erosion corrosion is a degradation of material surface due to mechanical action, often by impinging liquid, abrasion by a slurry, particles suspended in fast flowing liquid or gas, bubbles or droplets, cavitations etc. The mechanism can be described as follows:</p> <p><input type="checkbox"/> mechanical erosion of the material, or protective (or passive) oxide layer on</p>	2



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	<p>its surface,</p> <p><input type="checkbox"/> enhanced corrosion of the material, if the corrosion rate of the material depends on the thickness of the oxide layer.</p> <p>2) Intergranular corrosion (IGC), also known as intergranular attack (IGA), is a form of corrosion where the boundaries of crystallites of the material are more susceptible to corrosion than their insides. (Cf. transgranular corrosion.)</p> <p>This situation can happen in otherwise corrosion-resistant alloys, when the grain boundaries are depleted, known as <i>grain boundary depletion</i>, of the corrosion inhibiting elements such as chromium by some mechanism. In nickel alloys and austenitic stainless steels, where chromium is added for corrosion resistance, the mechanism involved is precipitation of chromium carbide at the grain boundaries, resulting in the formation of chromium-depleted zones adjacent to the grain boundaries (this process is called sensitization). Around 12% chromium is minimally required to ensure passivation, a mechanism by which an ultra thin invisible film, known as passive film, forms on the surface of stainless steels. This passive film protects the metal from corrosive environments. The self-healing properties of the passive film make the steel stainless. Selective leaching often involves grain boundary depletion mechanisms.</p>	2
2	Attempt any four	16
2-a	<p>Expression for reversible Isothermal Expansion of gases.</p> <p>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.</p> <p>The total work done by the gas in the expansion process as the piston moves from position 1 to position 2 during which volume is changing from V_1 to V_2 (and its</p>	4



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pressure is reduced from P_1 to P_2) is given by

$2 \rightarrow 2$

$$W = W_{1-2} = \int P dV = \int P dV$$

$1 \rightarrow 1$

The work done in reversible isotherm expansion of a gas is given by

V_2

$$W = P dV \int P dV (1)$$

V_1

The ideal gas equation is

$$PV = nRT$$

$$P = nRT/V (2)$$

Substituting for P from eq (2) eq (1) becomes)

$V_2 \rightarrow 2$

$$W = \int (nRT/V) dV = nRT \int dV/V$$

$V_1 \rightarrow 1$

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

$$P_1 V_1 = P_2 V_2$$

$$V_2 / V_1 = P_1 / P_2$$

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 , $U = 0$ and $T = 0$,

Hence $H = 0$

We have $U = Q - W$



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	<p>For an Isothermal Process $U = 0$. Therefore, the first law becomes $0 = Q - W$</p> <p>$Q = W$</p> <p>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.</p> <p>Work done in isothermal reversible expansion of an ideal gas is given by</p> $W = nRT \ln V_2 / V_1 = nRT \ln P_1 / P_2$	
2-b	<p>Gibb's 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 constant 2. mathematically, it is stated as follows:</p> $F = C - P + 2$ <p>i) Phase:</p> <p>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.</p> <p>ii) Component:</p> <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.</p> <p>iii) Degrees of freedom</p> <p>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</p>	<p>1</p> <p>1</p> <p>1</p> <p>1</p>



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	be specified in value to fully determine the state of the system. Typical such variables might be temperature, pressure, or concentration	
2-c	<p>The rate of corrosion increases with the increase in temperature.</p> <p>For most chemical reactions, the reaction rate increases with increasing temperature.</p> <ol style="list-style-type: none">1. Temperature affects the corrosion rate of metals in electrolytes primary 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 increases which tends to increase the corrosion rate.4. The net affect of 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 decrial in oxygen 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. <p>Effect of pH value on corrosion</p>	2



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	<p>Acidic media ($\text{pH} < 7$) are generally more corrosive than alkaline and neutral media. However amphoteric metals like Al, Zn, Pb can dissolve in alkaline solutions as complexions. Many materials are resistant to alkalis although they are readily attacked by acids. In such cases, their corrosivity can be reduced by increasing the pH of the solution. The rate of corrosion of Fe metal is slow in oxygen free water until $\text{pH} < 5$ and Zn suffers minimum corrosion at $\text{pH} = 11$. Thus the pH of media is a very important factor in considering the rate of corrosion.</p>	2
2-d	<p>Galvanic corrosion :</p> <p>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.</p> <p>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.</p> <p>GALVANIC SERIES of Dissimilar Metals.</p> <p>Largest, corrosive part, positive.</p> <ol style="list-style-type: none">1. Magnesium2. Zinc3. Cadmium4. Aluminum5. Steel	4



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	<p>6. Iron</p> <p>7. Stainless-Steel</p> <p>8. Solder</p> <p>9. Lead</p> <p>10. Tin</p> <p>11. Nickel</p> <p>12. Brass</p> <p>13. Copper</p> <p>14. Bronze</p> <p>15. Silver Solder</p> <p>16. Silver</p> <p>17. Titanium</p> <p>18. Graphite</p> <p>19. Gold</p> <p>20. Platinum</p> <p>21. Smallest, protected part, negative</p>	
2-e	<p>Commonly used acids & alkalis and their material of construction:</p> <p>i)Hydrochloric Acid: fiberglass-reinforced plastic (FRP) tank</p> <p>ii)Sulphuric Acid: Store in a metallic or coated fiberboard drum using a strong polyethylene inner package</p> <p>iii)Nitric Acid: Aluminium and its alloy</p> <p>iv)Caustic Soda: Stainless steel</p> <p><i>Any other acids and alkalies may be given due consideration</i></p>	<p>1</p> <p>1</p> <p>1</p> <p>1</p>
2-f	<p>Given : $n=1$, if $v_1 = v$, $v_2 = 10v$.</p> <p>find $w=?$</p> <p>for reversible isothermal process $W = nRT \ln V_2/V_1 = nRT \ln P_1/P_2$</p>	<p>1</p> <p>1</p>

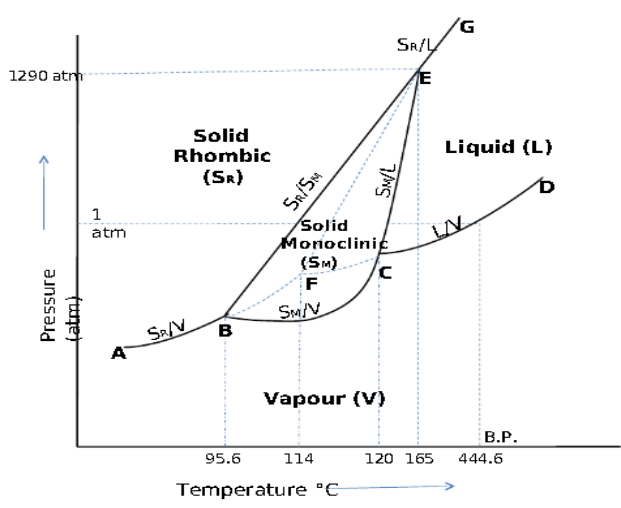


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	$W = 1 \times 8.314 \times 273 \times \ln 10$ $W = 5226.2284 \text{ J}$	1 1
3	Attempt any four	16
3-a	As the process is isothermal $\Delta U = 0$ $\Delta U = Q - W$ $\Delta H = 0$ $W = nRT \ln(P_1/P_2)$ $= 2 \times 8.314 \times 32 \times \ln(3/1)$ $W = 584.56 \text{ J}$ $Q = W$ $Q = 584.56 \text{ J}$	2 1 1
3-b	<p>Phase Diagram for sulphur System:</p>  <p>The Sulphur System</p> <p>Sulphur can exist in four possible phases:</p> <p>Two solid polymorphic phases</p>	2



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	<p>Rhombic Sulphur (SR) (m.p. 114°C) Monoclinic Sulphur (SM) (m.p. 120°C) Sulphur Liquid Sulphur Vapours Curves In Phase Diagram</p> <ul style="list-style-type: none">• Curve AB: Sublimation Curve of Rhombic Sulphur• Curve BC: Sublimation Curve of Monoclinic Sulphur• Curve CD: Vapor Pressure Curve of Liquid Sulphur• Curve CE: Fusion Curve of Monoclinic Sulphur• Curve BE: Transition Curve Solid Sulphur• Curve EG: Fusion Curve of Rhombic Sulphur• At any curve, phase rule becomes, $F = 3 - P = 3 - 2 = 1$ (Monovariant)	2
3-c	<p>Some of the important <u>applications of adsorption</u> are as follows:</p> <p>(1) In the preparation of gas masks using activated charcoal to avoid poisonous gases like CO, CH_4 etc.</p> <p>(2) Froth floatation method used for concentration of sulphide ores is based on adsorption.</p> <p>(3) Silica gel can be used to remove moisture and to control humidity.</p> <p>(4) Ion exchange method used to soften water is based on adsorption.</p> <p>(5) Adsorption chromatography is used to purify and separate pigments, hormones</p>	1 mark each for any 4



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	etc. (6) Charcoal powder can remove coloured impurities from sugar. (7) Charcoal is used for making high vacuum. (8) The cleaning action of soaps and detergents. (9) Formation of stable emulsions in cosmetics and syrups etc. (10) In heterogeneous catalysis.																												
3-d	<table><tr><th colspan="3">Dry corrosion and wet corrosion:</th></tr><tr><th>Sr.no</th><th>Dry corrosion</th><th>Wet corrosion</th></tr><tr><td>1</td><td>It occurs in dry condition.</td><td>It occurs in wet condition.</td></tr><tr><td>2</td><td>If the corrosion takes place due to direct chemical attack (in the absence of moisture), corrosion is known as dry corrosion.</td><td>If the corrosion takes place due to electrochemical attack in presence of moisture or a conducting medium, corrosion is known as wet corrosion</td></tr><tr><td>3</td><td>Explained by absorption mechanism</td><td>Explained by electrochemical mechanism</td></tr><tr><td>4</td><td>It occurs on both heterogeneous and homogeneous surfaces.</td><td>It occurs only on heterogeneous metal surfaces.</td></tr><tr><td>5</td><td>Corrosion is uniform.</td><td>Corrosion is not uniform.</td></tr><tr><td>6</td><td>It is a slow process.</td><td>It is a fast process.</td></tr><tr><td>7</td><td>Corrosion products accumulate at the place where corrosion occurs.</td><td>Corrosion take place at anode but products accumulate near the cathode.</td></tr></table>	Dry corrosion and wet corrosion:			Sr.no	Dry corrosion	Wet corrosion	1	It occurs in dry condition.	It occurs in wet condition.	2	If the corrosion takes place due to direct chemical attack (in the absence of moisture), corrosion is known as dry corrosion.	If the corrosion takes place due to electrochemical attack in presence of moisture or a conducting medium, corrosion is known as wet corrosion	3	Explained by absorption mechanism	Explained by electrochemical mechanism	4	It occurs on both heterogeneous and homogeneous surfaces.	It occurs only on heterogeneous metal surfaces.	5	Corrosion is uniform.	Corrosion is not uniform.	6	It is a slow process.	It is a fast process.	7	Corrosion products accumulate at the place where corrosion occurs.	Corrosion take place at anode but products accumulate near the cathode.	1 mark each for any 4
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3-e	PROPERTIES of PTEE: PTFE is a <u>fluorocarbon</u> solid, as it is a high- <u>molecular-weight</u> compound consisting																												

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	<p>wholly of <u>carbon</u> and <u>fluorine</u>. PTFE is <u>hydrophobic</u>: neither water nor water-containing substances wet PTFE, as fluorocarbons demonstrate mitigated <u>London dispersion forces</u> due to the high <u>electronegativity</u> of fluorine. PTFE has one of the lowest coefficients of <u>friction</u> of any solid.</p> <p>USES:</p> <p>PTFE is used as a <u>non-stick</u> coating for pans and other <u>cookware</u>. It is very non-reactive, partly because of the strength of <u>carbon–fluorine bonds</u>, and so it is often used in containers and pipe work for reactive and corrosive chemicals. Where used as a <u>lubricant</u>, PTFE reduces friction, wear and energy consumption of machinery. It is commonly used as a graft material in surgical interventions. Also, it is frequently employed as <u>coating</u> on <u>catheters</u>; this interferes with the ability of bacteria and other infectious agents to adhere to catheters and cause <u>hospital-acquired infections</u>.</p>	2	
3-f	<p>PROPERTIES of SS 304:</p> <ul style="list-style-type: none"> • High ductility, • excellent drawing, • forming, and • spinning <i>properties</i> <p>USES:</p> <ul style="list-style-type: none"> • Excellent corrosion resistance soused in chemical ,petro chemical and fertilizer industry • Dairy and food industry • Pharmaceutical industry 	2	



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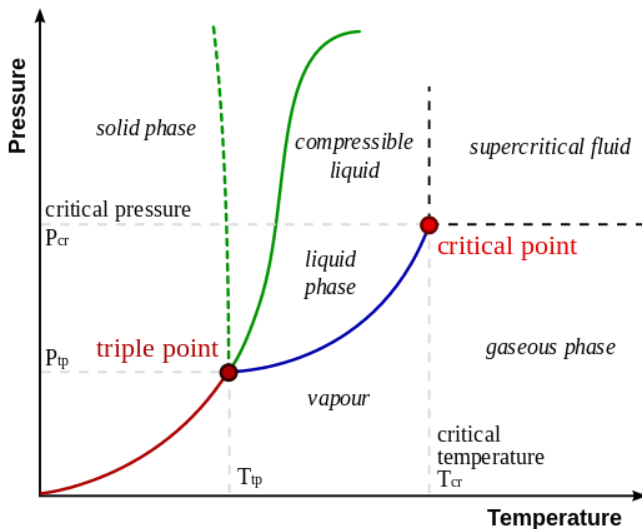
	<ul style="list-style-type: none">• Hospitals• Cryogenic vessels• For machinery in paper and pulp ,textile industry• Heat exchanger in air conditioning refrigeration	
4	Attempt any four	16
4-a	A system is said to be in thermodynamic equilibrium when it is in a state of mechanical, thermal, and chemical equilibrium. There is no unbalanced force in the inertial of the system or between the system and its environment. All parts of the system are at the temperature, and this is the same as the temperature of the environment. The net rate of any chemical reaction or change of internal structure is zero. When a system is in thermodynamic equilibrium, its condition can be specified by giving the values of only a few quantities (such as pressure, volume, temperature, and quantity of a particular substance) called variables of state. By a thermodynamic process, or a change of state, is meant any change (however small) that involves changes in these variables. A change of phase, however, refers to a more fundamental change of physical form, as from a liquid to a vapor or from one crystalline form to another.	4
4-b	A phase diagram is a graph showing the limiting conditions for solid, liquid, and gaseous phases of a single substance or of a mixture of substances while undergoing changes in pressure and temperature or in some other combination of variables, such as solubility and temperature. Phase diagram for water system:	1 mark for definitio n 1.5

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1.5

The phase diagram shows, in pressure–temperature space, the lines of equilibrium or phase boundaries between the three phases of solid, liquid, and gas. The fusion curves for water and Antimony are with negative slopes, All other liquids have positive slope on P-T diagram.

The curves on the phase diagram show the points where the free energy (and other derived properties) becomes non-analytic: their derivatives with respect to the coordinates (temperature and pressure in this example) change discontinuously (abruptly). For example, the heat capacity of a container filled with ice will change abruptly as the container is heated past the melting point. The open spaces, where the free energy is analytic, correspond to single phase regions. Single phase regions are separated by lines of non-analytical behavior, where phase transitions occur, which are called **phase boundaries**.

In the diagram on the left, the phase boundary between liquid and gas does not continue indefinitely. Instead, it terminates at a point on the phase diagram called the critical point. This reflects the fact that, at extremely high temperatures and pressures, the liquid and gaseous phases become indistinguishable in what is



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	known as a <u>supercritical fluid</u> . In water, the critical point occurs at around $T_c = 647.096 \text{ K}$ ($373.946 \text{ }^\circ\text{C}$), $p_c = 22.064 \text{ MPa}$				
4-c	Lyophilic and Lyophobic sol:				1 mark each for any 4
	Sr.no	Property	LYOPHILIC COLLOIDS	LYOPHOBIC COLLOIDS	
	1	Mode of preparation.	Forms easily by mere shaking or warming the dispersed phase with dispersion medium E.g. Gelatine in water.	Forms only by special methods. Example: AS_2S_3 in water.	
	2	Size of particle	The particles are true molecules and are just bigger in size (Molecular colloids).	The particles are aggregates of thousands of molecules (Associated colloids).	
	3	Nature	Reversible and once precipitated can readily pass into colloidal state by direct contact with dispersion medium because particles are solvent loving.	Irreversible and once precipitated can not easily pass into colloidal state because particles are solvent hating.	
	4	Visibility	The particles are not easily detected even under ultra microscope.	The particles are easily detected under ultra microscope.	
	5	Charge	The charge of particles depends	The particles carry positive or	



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			upon P_H of medium and it may be positive, negative or neutral.	negative charge.	
6	Stability		These are stable and are self – stabilized.	These are unstable and hence require traces of electrolyte for stabilisation.	
7	Action of electrolytes		Co-agulation can be brought about by the addition of large amount of electrolyte.	Co-agulation can be brought about by small amount of electrolyte.	
8	Viscosity		It is much higher than that of dispersion medium.	It is about same as that of dispersion medium.	
9	Surface		It is lower than dispersion medium	It is about same as that of dispersion medium.	
10	Tyndall effect		Less distinct	More distinct.	
11	Electrophoresis		The particles may or may not show electrophoresis.	The particles show electrophoresis.	
12	Hydration		The particles are heavily hydrated due to love for solvent.	The particles are not appreciably hydrated due to hate for solvent.	
13	Conc. Of dispersed phase		Higher concentrations of dispersed phase are possible.	Only low concentrations of dispersed phase are possible.	



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	14	Colligative property	They have relatively high osmotic pressure, depression in freezing point and high lowering in vapour pressure.	They have high osmotic pressure, less depression in freezing point, less elevation in boiling point and less lowering of vapour pressure.	
4 d	<p>The mechanism of the sacrificial anode protection system is very similar to the reaction mechanism of electrochemical cells. In sacrificial anodes the protected metal is placed on the cathode side and then a more reactive metal or alloy (having a larger potential difference than the protected metal) is chosen and connected to the protected metal as an anode. The redox reaction will proceed spontaneously. An oxidation reaction occurs at the anode, which means that the sacrificial metal will be consumed. At the same time, the reduction reaction occurs on the cathodic side, preventing the protected metal from erosion. Thus, corrosion on the protected metal is successfully shifted to the anode, protecting the metal.</p> <p>Sacrificial anodes are normally supplied with either lead wires or cast-in straps to facilitate their connection to the structure being protected. The lead wires may be attached to the structure by welding or mechanical connections.</p> <p>The materials used for sacrificial anodes are either relatively pure active metals, such as zinc or magnesium, or are magnesium or aluminum alloys that have been specifically developed for use as sacrificial anodes.</p> <p>Advantages of using sacrificial anodes:</p> <ul style="list-style-type: none">• Can be used where there is no power• Lower initial cost• Less supervision required				4



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	<ul style="list-style-type: none">• Comparatively simple installation and additional anodes can easily be added if the initial installation proves to be inadequate <p>Sacrificial anodes are used to protect:</p> <ul style="list-style-type: none">• Hulls of ships• Water heaters• Pipelines• Distribution systems• Above-ground tanks• Underground tanks• Refineries	
4-e	<p>Equipment required lining:</p> <ul style="list-style-type: none">• Reactor• Heat exchanger• REACTORS• DISTILLATION COLUMNS• SETTLERS• DRYERS• AGITATED REACTION VESSELS• AUTOCLAVES• MIXERS• BLENDERS• LEAD & RUBBER LINED VESSELS• STACKS, CHIMNEYS, FLAX• AGITATORS• CRYSTALLIZERS• FERMENTORS• PERCOLATORS	2



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	<p>Purpose of lining</p> <ul style="list-style-type: none">i) chemical resistance,ii) low permeability,iii) physical durability andiv) economical installation.	2
4-f	<p>Aggregation Methods</p> <p>methods consists of chemical reactions or change of solvent whereby the atoms or molecules of the dispersed phase appearing first, aggregate to form colloidal particles. The conditions (temp., conc. etc) used are such as permit the formation of sol particles but prevent the particles becoming too large and forming precipitate. The important chemical methods for preparing lyophobic sols are as follows;</p> <p>a. Double Decomposition:</p> <p>An Arsenic Sulphide (AS_2S_3) sol is prepared by passing a slow stream of hydrogen sulphide gas through cold solution of arsenious oxide (AS_2O_3). This is continued till a yellow colour of sol attains maximum intensity.</p> $AS_2O_3 + 3 H_2S \longrightarrow AS_2S_3(\text{Yellow Sol}) + 3H_2O$ <p>Sols of silver halide are obtained by mixing dilute solutions of silver salts and alkali halides in equivalent amounts. Silica gel sol is prepared by this method between dilute solutions of sodium silicate and HCl.</p> <p>b. Oxidation:</p> <p>A Colloidal sol of sulphur can be obtained by passing hydrogen Sulphide into solution of sulphur dioxide in water or through a solution of an oxidising agent (Bromine water, nitric acid).</p> $SO_2 + 2H_2S \longrightarrow 3S + 2H_2O$ $H_2S + (O) \longrightarrow S + H_2O$ <p>c. Reduction:</p> <p>A colloidal solution of a metal like silver, gold and platinum can be prepared by reducing their salt solutions with suitable reducing agents, such as stannous chloride, formaldehyde, hydrazine, tannic acid etc.</p> $2AuCl_3 + 3SnCl_2 \longrightarrow 2Au(\text{Gold sol.}) + 3 SnCl_4$ <p>or $AuCl_3 + \text{Tannic acid} \longrightarrow Au(\text{Sol.})$</p>	2 marks each for any 2 methods



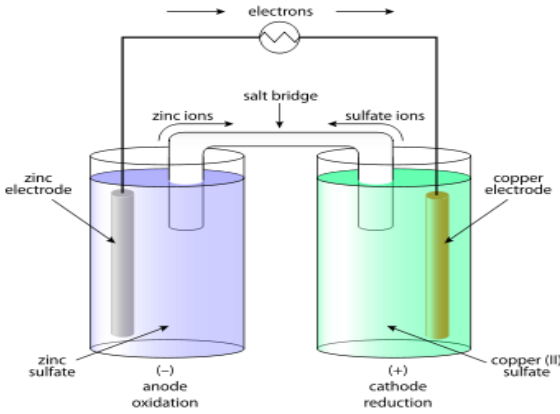
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	<p>d. Hydrolysis:</p> <p>The method is used to prepare hydroxides and oxides of weakly electropositive metals like Fe, Al or Sn. A red sol of ferric hydroxide, is obtained by adding few drops of 30% ferric chloride solution to a large volume of almost boiling water and stirred with a glass rod. $\text{FeCl}_3 + 3\text{H}_2\text{O} \rightarrow \text{Fe}(\text{OH})_3 (\text{Red Sol.}) + 3\text{HCl}$.</p>	
5	Answer any 4	16
5-a	<p>Mechanism of hydrogen evolution wet corrosion</p> <p>If hydrogen reduction reaction is responsible for corrosion of Fe, it needs two electrons to form H_2 ($2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2$). It happens in two steps: 1. discharge step (an hydrogen ion in the solution combines with an electron from the dissolution of Fe ($\text{Fe} \rightarrow \text{Fe}^{2+} + 2\text{e}^-$) and forms a nascent hydrogen atom on the metal surface) and 2. chemical (two nascent hydrogen atoms combine to give gas (H_2)) or electrochemical recombination step (this step involves an electron, the discharge step happens in the presence of an adsorbed nascent hydrogen on the metal surface). If these adsorbed atoms diffuse into the metal and they get collected in a void if present. The recombination step happens inside the void to produce hydrogen gas. As the time goes on, it builds up the pressure inside the void, stresses up beyond the yield point and bursts. It even embrittles the metal.</p>	4
5-b	<p>Galvanic Cell:</p> 	2



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	<p>A galvanic cell consists of two half-cells, such that the electrode of one half-cell is composed of metal A, and the electrode of the other half-cell is composed of metal B; the redox reactions for the two separate half-cells. The solutions are connected by a salt bridge or a porous plate in order to conduct the ions (both the metal-A cations from one solution, and the anions from the other solution), which balances the charges of the solutions and thereby allows the reaction between metal A and metal B to continue without opposition. Copper readily oxidizes zinc; for the the anode is zinc and the cathode is copper, and the anions in the solutions are sulfates of the respective metals. When an electrically conducting device connects the electrodes, the electrochemical reaction is:. The zinc electrode is dissolved and copper is deposited on the copper electrode. Galvanic cells are typically used as a source of electrical power. By their nature, they produce direct current.</p>	2														
5-c	<p>Differences between reversible and irreversible process.</p> <table><tr><th>Reversible Process</th><th>Irreversible Process</th></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><tr><td>2. It is imaginary as it assumes the presence of frictionless and weight less piston.</td><td>2. It is real and can be performed actually.</td></tr><tr><td>3. It is in equilibrium state at all stage of the operation.</td><td>3.It is in equilibrium state only at the initial and final stage of the operation.</td></tr><tr><td>4. All changes are reversed when the process is carried out in reversible direction.</td><td>4. After this type of process has occurred all changes do not return to the initial stage by themselves.</td></tr><tr><td>5. It is extremely slow.</td><td>5. It proceeds at measureable speed.</td></tr><tr><td>6. Work done by a reversible process is greater than the</td><td>6. Work done by a irreversible process is smaller than the corresponding reversible</td></tr></table>	Reversible Process	Irreversible Process	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 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.	3.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	6. Work done by a irreversible process is smaller than the corresponding reversible	1 mark each for any 4
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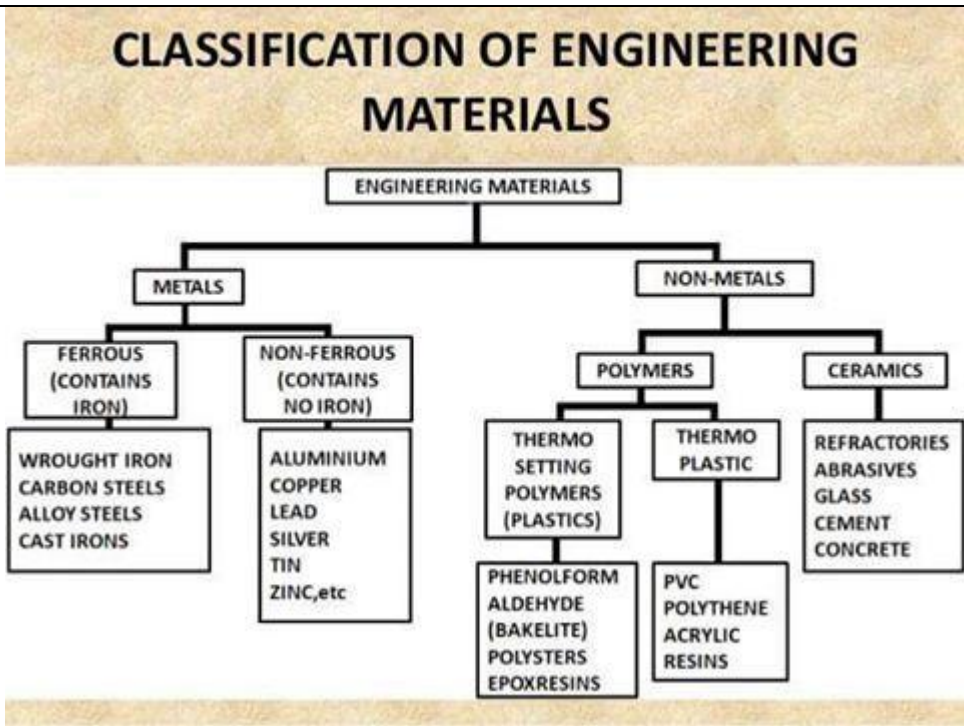
	corresponding irreversible process.	process.	
5-d	<p>Peptization is the process responsible for the formation of stable dispersion of colloidal particles in dispersion medium. In other words it may be defined as a process of converting a precipitate into colloidal sol by shaking it with dispersion medium in the presence of small amount of electrolyte. The electrolyte used in this process is called as peptizing agent.</p> <p>This is particularly important in colloid chemistry or for precipitation reactions in an aqueous solution. When colloidal particles bear a same sign electric charge, they mutually repel each other and cannot aggregate together. Freshly precipitated aluminum or iron hydroxide is extremely difficult to filter because the very fine colloidal particles directly pass through a paper filter. To facilitate the filtration, the colloidal suspension must be first flocculated by adding a concentrated solution of salt to the system. Multivalent cations are more efficient flocculants than monovalent cations: $AlCl_3 > CaCl_2 > NaCl$. The electrical charges present at the surface of the particles are so "<i>neutralized</i>" and disappear. More correctly speaking, the electrical double layer existing at the surface of the particles is compressed by the added electrolyte and collapses at high ionic strength. The electrical repulsion no longer hinders the aggregation of particles and they can then coalesce to form a flocculent precipitate that is easy to filter. If the precipitate is washed with an excessive volume of deionizer water, the electrical double layer present at the surface of the particles expands again and the electrical repulsion reappears: the precipitate peptizes and the particles pass again through the filter.</p>		4
5-e			4

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5-f	<p>Different types of linings are :</p> <ol style="list-style-type: none"> Lead lining: it is having high corrosion resistance but it is soft and has poor mechanical property. Because of this it is used for protection of mild steel. Glass lining: glass has excellent resistance to all acids except hydrofluoric. Their general applications are for equipments such as reactors, columns, pipes etc. rubber lining: here lining is generally in the form of sheets or thin films applied by using specific adhesive. plastic lining: the method of plastic lining preparation of the surface plays important part in subsequent adhesion of film to the metal surface. 	<p>1</p> <p>1</p> <p>1</p> <p>1</p>
6	Answer any 4	16
6-a	<p>Important Alloys of Aluminium:</p> <ol style="list-style-type: none"> Aluminium-copper alloys Aluminium-silicon alloys 	<p>2 marks</p> <p>each for</p>



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	<p>3. Aluminium-magnesium alloys 4. Aluminium-zinc alloys 5. Aluminium- silicon- magnesium alloys .</p> <p>1.Duraluminium It is Aluminium-copper alloys. Composition: 4% Cu+smallamount of Mg,Mn+balance Al Properties: 1. It is light weight ,tough and strong alloy of Al. 2. It has good forming property. 3. It has good corrosion resistance .</p> <p>Uses: In air craft industry. For cladding purpose. Al-Cu alloy sheets are clad with high purity aluminum.</p> <p>2. LM-6: It is an alumunium –silicon alloy. Composition: 12% Si and balanced Al. Properties: high corrosion resistance and fluidity. Uses: intricate castings for automobiles and pump parts.</p> <p>3. LM-5: Aluminium-magnesium alloys. Composition: 5% Mg and balance Al. Properties: good weldability,hardness, corrosion resistance, and strength,possesses bright surface finish. Uses: cable sheathing, in marine applications, cryogenic equipments.</p>	<p>any two alloys</p>
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6-b	Inhibitors are organic or inorganic chemicals which are added in small amounts to a corrosion medium in order to reduce the corrosive effect of the medium. 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 the silicates tend to suppress the anodic reaction or metal dissolution. Cathodic inhibitors control the cathodic reaction (they shield the cathodic areas) many organic components such as amines,thiourea and mercaptants work as cathodic inhibitors. The cathodic and anodic inhibitors working together are more effective than acting separately.	4	
6-c	Define system, surroundings, boundary 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.	1.5	
	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.	1.5	
	Boundary: A boundary is a closed surface surrounding a system through which energy and mass may enter or leave the system.	1	
6-d	Difference between extensive and intensive properties.		2 mark each for any 2
	Extensive properties	Intensive properties	
	It is depending on the mass of the system	It is independent of mass /amount of the system	
	It depends on the amount/quantity of the substance present in the	These are not depending on the size of the system. These are not additive.	



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	system. These are additive.			
	Volume will be different at the stages of the system	The value of the property is the same at all points.		
6-e	<p>Glass Lining: Glass resistance is excellent resistance to all acids .it is subjected to alkali attack. Glass is also damage by thermal shock. Methods foe glass lining are: Wet spray process: The metal surface of a vessel on which glass lining is to be done is cleaned. A suspension called slip consisting of enamel powder and emulsifying agent I sprayed like a paint on metal surface, then the coat is drayed and then the vessel is transfer to a furnace and fired at temp that result in fusion of partials.</p> <p>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.</p> <p>Glass resistance is excellent resistance to all acids .it is subjected to alkali attack. Glass is also damage by thermal shock. Methods foe glass lining are:Wet spray process: The metal surface of a vessel on which glass lining is to be done is cleaned. A suspension called slip consisting of enamel powder and emulsifying agent I sprayed like a paint on metal surface, then the coat is drayed and then the vessel is transfer to a furnace and fired at temp that result in fusion of partials.</p> <p>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.</p> <p>Application: Reactor</p>			4



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	Acid storage tank Pipeline Column																			
6-f	<table><tr><td colspan="2">Differentiate between physical and chemical adsorption</td></tr><tr><td>PHYSICAL ADSORPTION</td><td>CHEMICAL ADSORPTIONS</td></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. desorption of the gas occurs by increasing the temperature or decreasing the pressure.</td><td>The process is irreversible. Efforts to free the adsorbed gas give some definite compound.</td></tr><tr><td>It does not require any activation energy.</td><td>It requires any activation energy.</td></tr><tr><td>This type of adsorption decreases with increase of temperature.</td><td>This type of adsorption first increases with increase of temperature. The effect is called activated adsorption.</td></tr><tr><td>It is not specific in nature i.e. all gases are adsorbed on all solids to some extent.</td><td>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.</td></tr></table>	Differentiate between physical and chemical adsorption		PHYSICAL ADSORPTION	CHEMICAL ADSORPTIONS	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.	1 mark each for any 4
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