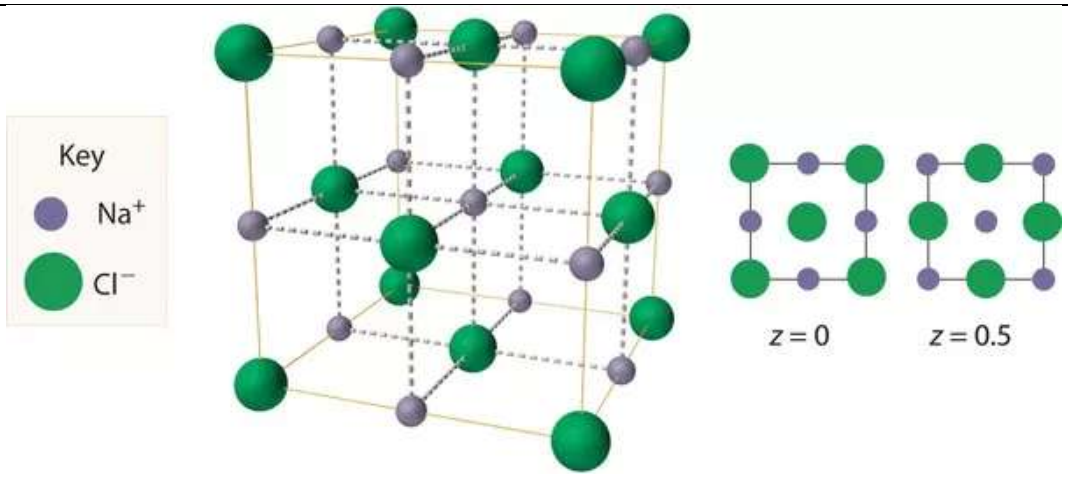
Important Instructions to examiners:

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	Sub q.no.	Answer	marks
1		**Any five**	**10**
1	a	**Properties of biomaterials** (any 2) i) Must be hard ii) must be flexible iii) must not react with any tissue in the body iv) must not be toxic to the body v) long term replacement must not be biodegradable.	1 mark each
1	b	**Heat capacity.** • Heat capacity is the quantity of heat energy needed to raise the temperature of a specific material by one degree Celsius. OR • Heat capacity is the ratio of the quantity of heat energy transferred to a material and the resultant temperature rise.	2
1	c	**Bragg's law.** "The general relationship between the wavelength of the incident X-rays , angle of incident / glancing angle and spacing between the crystal planes of atoms is known as Bragg's law."	2
1	d	**Corrosion.** • Corrosion is the gradual deterioration or destruction of materials (usually metals and alloys) by chemical or electrochemical reactions with its environment.	2

		OR • Corrosion is defined as the gradual deterioration or destruction of a metal by chemical or electrochemical reactions with its environment. OR • Any process of deterioration and consequent loss of a solid metallic material through undesired chemical or electrochemical attack by its environment starting at the surface.	
1	e	**Thermal conductivity of materials.** • Thermal conductivity of engineering material is the property of a material that determines the rate at which it can transfer heat. • It is a measure of the ability of a material to transfer heat. • Thermal conductivity of material is the property to conduct heat.	2
1	f	**Types of iron are:.** 1) Pig iron 2) Wrought iron 3) Cast iron 4) Pure iron (butte iron)	2
1	g	**Effect of any two chemical elements on iron.(any 2)** • **Carbon** : It increases tensile strength and hardness but lowers ductility and weldability. • **Chromium** : It increases hardenability. It increases corrosion resistance and oxidation resistance. It increases resistance to scaling at high temperature.	1 mark each

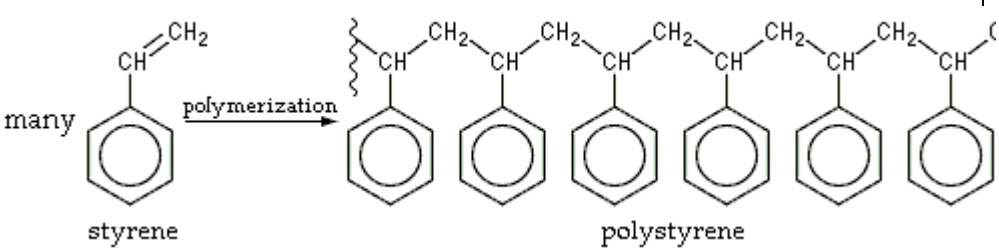
		• **Copper** : It improves resistance to atmospheric corrosion. It strengthens steel. It may be added to improve formability. It improves paint adhesion. • **Nickel** : It increases hardenability, improves toughness , ductility and corrosion resistance. • **Manganese** : It increases tensile strength , abrasion (wear) resistance , hardenability and toughness. It decreases weldability. • **Silicon** : It is used as a deoxidizer. It helps to remove bubbles of oxygen from the molten steel. It prevents blowholes and thereby makes steel tougher and harder. • **Phosphorous** : It is considered as an undesired impurity in steel because of its embrittling effect. It improves strength but at the same time decreases ductility. It is upto 0.04% by weight. • **Suplhur** : It is an undesired impurity in steel. It causes brittleness. It improves machinability but decreases ductility and weldability. Its content is limited to 0.05%.	
2		**Any three**	**12**
2	a	**Crystal structure of NaCl.**	2



The salient features of its structure are:

- Chloride ions are ccp type of arrangement, i.e., it contains chloride ions at the corners and at the center of each face of the cube.
- Sodium ions are so located that there are six chloride ions around it. This equivalent to saying that sodium ions occupy all the octahedral sites.
- As there is only one octahedral site for every chloride ion, the stoichiometry is 1 : 1.
- It is obvious from the diagram that each chloride ion is surrounded by six sodium ions which are disposed towards the corners of a regular octahedron. We may say that cations and anions are present in equivalent positions and the structure has 6 : 6 coordination.
- The structure of sodium chloride consists of eight ions a unit cell, four are Na+ ions and the other four are Cl– ions.
- In this structure, each corner ion is shared between eight unit cells, each ion a face of the cell by two cells, each ion on a edge by four cells and the ion inside the cell belongs entirely to that unit cell.

2

2	b	**Explain addition polymerization for polystyrene.** Ans : Synthesis – • Styrene ($C_6H_5CH=CH_2$) , undergoes addition polymerization to form polystyrene , --($C_6H_5CH=CH_2$)- • It is prepared by the polymerization of styrene in presence of benzoyl peroxide catalyst. • The raw materials for polystyrene are ethylene and benzene that react to form ethyl benzene, which is further processed into styrene monomer. • Polystyrene is a cheap transparent compound.  • In the polymerisation, the carbon–carbon π bond of the vinyl group is broken and a new carbon–carbon σ bond is formed, attaching to the carbon of another styrene monomer to the chain. • The newly formed σ bond is stronger than the π bond that was broken, thus it is difficult to depolymerize polystyrene.	4
2	c	**Mechanism of corrosion in acidic medium.** • An acidic environment refers to an environment having a pH value of less than 7.Acidic environments are more prone to cause corrosion than alkaline and neutral environments. • When an acid reacts with a metal, salt is produced with the evolution of	4

		hydrogen gas. The general chemical reaction between an acid and a metal is , Metal + Acid -----> Salt + Hydrogen gas For example , $Zn + H_2SO_4$ -----> $ZnSO_4 + H_2$ • Acid contains H^+ ions and tend to accept electrons. They tend to grab electrons and form hydrogen gas. Metals give up electrons and form metal ions. For example , Fe -----> $Fe^{2+} + 2e^-$ And $2H^+ + 2e$- -----> H_2 • Thus , when we put an iron nail in an acid , the H^+ ions resent in the acid grab electrons from the iron. Iron gives up electrons and gets converted into soluble Fe^{2+} ions and the solid material (nail) gradually disappears. The electochemical reaction (which is the sum of oxidation and reduction reaction) is , $Fe + 2H^+$ ----->$Fe_{2+} + H_2$ • If the acid used is HCl, then the corrosion product is $FeCl_2$.	
2	d	**Properties of ferrous alloys: (any 4)** a) Heat resistant alloy steel – i. hard wearing and offer resistance to large variation in temperatures. ii. corrosion resistance iii. oxidation resistance iv. creep resistance v. hydrogen brittleness under very high temperature.	1 mark each

		b) stainless steel – i. good corrosion resistance due to chromium content. ii. Non-magnetic iii. Good weldability iv. Good heat resistant.	
3		**Any three**	**12**
3	a	**Organic and inorganic insulation:** **Organic insulation:** Organic insulation materials are mainly polyurethane foam, polystyrene board, phenolic foam . organic insulation materials mainly from petroleum products, including foam polystyrene board (EPS), extruded polystyrene board (XPS), spray polyurethane (SPU) and polystyrene particles organic insulation material with light weight, good process ability , high compactness, good insulation effect Disadvantage is: aging resistance, deformation coefficient, poor stability, poor security, easy combustion, ecological environmental protection is poor, difficult construction, construction cost is higher, and the limited resources. It is difficult to recycle **Inorganic insulation:** Inorganic heat preservation material including expanded perlite, hollow glass beads, rock wool, mineral wool, perlite, glass wool and lightweight block self insulation system, mainly based on inorganic materials such as stone, glass, industrial waste and so on. Inorganic insulation materials with energy-saving, waste, heat insulation, fire protection, antifreeze, anti-aging and excellent performance, low prices , high level	2 2

		fire protection.	
3	b	Given: R = 2 ohms L = 15 cm = 0.15 m A = 25 sq.cm = 25 x 10^{-4} sq.m $R = \rho\frac{L}{A}\ \Omega$ Resistivity = (R x A) / L = (2 x 25 x 10^{-4}) / 0.15 =0.0333 ohm m	2 1 1
3	c	**Properties of ceramics: (any 4)** High Strength. High Fracture Toughness. High Hardness. Excellent Wear Resistance. Good Frictional Behavior. Anti-Static.	1 mark each
3	d	**Chemical composition of**: **1.Stainless steel**: Min 12 % chromium 12 to 30 % Cr 4 to 25 % Ni **2.Tungsten steel**: 18 % Tungsten (W) 4 % Cr 1 % vanadium	1 1

		0.7 % carbon Small amount of Si , S , P ,Mn , Fe. **3.Nickel:** 20 to 23 % Cr 58 % Ni 8 to 10 % molybdenum 1 % cobalt 0.10 % carbon **4.Manganese steel:** (e.g. C-Mn steel) 0.15 % C 1.4 % Mn 0.218 % Si 0.007 % S	1 1
4		**Any three**	**12**
4	a	**Mechanical properties of Engg. Materials(any 4)** 1.Elasticity: Ability of a deformed material body to return to its original shape and size when the forces causing the deformation are removed. A body with this ability is said to behave (or respond) elastically 2.Plasticity: The deformation of a (solid) *material* undergoing non-reversible changes of shape in response to applied forces. For example, a solid piece of metal being bent or pounded into a new shape displays *plasticity* as permanent changes occur within the *material* itself. 3.Ductility: *Ductility* is the ability of a solid *material* to deform under tensile stress. a *ductile*	1 mark each

		material is a *material* that can easily be stretched into a wire when pulled . 4.Brittleness: A *material* is *brittle* if, when subjected to stress, it breaks without significant plastic deformation. *Brittle materials* absorb relatively little energy prior to fracture, even those of high strength. Breaking is often accompanied by a snapping sound. 5.Hardness: Material hardness is the property of the material which enables it to resist plastic deformation, usually by penetration or by indentation. The term of hardness is also referred to stiffness or temper, or to resistance to bending, scratching, abrasion, or cutting.	
4	b	**Method of corrosion prevention:** 1. Choice of material 2. Proper design and fabrication of components 3. Use of high purity metal 4. Special heat treatment 5. Modification of corrosion environment 6. Use of alloying 7. Use of inhibitors 8. Cathodic protection 9. Use of protective surface coating Hot dip galvanizing: this corrosion prevention method involves dipping steel into molten zinc. The iron in the steel react with the zinc to create a tightly bonded alloy coating which act as protection.it has lower initial cost, sustainability and versatility. ***Note: Explanation of any one method may be given mark***	2 2
4	c	Given:	

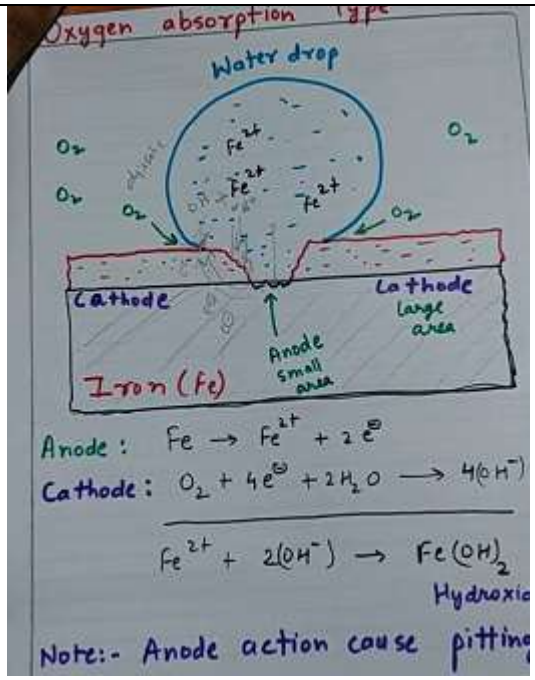
		L= 20 M A = 1 Sq. mm = 1 x 10^{-6} sq. m R = 5 ohm $R = \rho\frac{L}{A}\ \Omega$ Resistivity = (R X A) / L = (5 X 1 x 10^{-6}) / 20 =0.25 X 10^{-6} Conductivity = 1/ resistivity =1 / (0.25 X 10^{-6}) =4 X 10^{6}	1 1 1 1
4	d	**Properties of thermosetting polymers:(any 4)** 1.Very poor elasticity 2.sronger attractive forces between chains 3. not soluble in organic compounds 4.can not be remoulded 5. these polymers produces by condensation polymerization	1 mark each
4	e	**Condensation polymerization for phenol formaldehyde:** Phenol formaldehyde resins are synthetic polymers obtained by the reaction of phenol with formaldehyde(Bakelite). used for the production of molded products including billiard balls, laboratory countertops, and as coatings and adhesives. Used for fire-resistant circuit board materials. There are two main production methods. One reacts phenol and formaldehyde directly to produce a thermosetting polymer, while the other restricts the formaldehyde to produce a prepolymer which can be moulded and then cured with the addition of more formaldehyde and heat.	4

		Phenol reacts with formaldehyde at the ortho and para sites (sites 2, 4 and 6) allowing up to 3 units of formaldehyde to attach to the ring. The initial reaction in all cases involves the formation of a hydroxymethyl phenol: $HOC_6H_5 + CH_2O \rightarrow HOC_6H_4CH_2OH$ The hydroxymethyl group is capable of reacting with either another free ortho or para site, or with another hydroxymethyl group. The first reaction gives a methylene bridge, and the second forms an ether bridge: $HOC_6H_4CH_2OH + HOC_6H_5 \rightarrow (HOC_6H_4)_2CH_2 + H_2O$ $2\ HOC_6H_4CH_2OH \rightarrow (HOC_6H_4CH_2)_2O + H_2O$	
5		**Any two**	**12**
5	a	**Thermal properties of Engg. Materials:** 1.Temperature: Temperature is the degree to measure hotness and coldness. *Temperature* is a physical quantity expressing hot and cold. 2.Thermal conductivity: The rate at which heat passes through a specified material, expressed as the amount of heat that flows per unit time through a unit area with a temperature gradient of one degree per unit distance. 3.Thermal diffusivity: Thermal conductivity of a substance divided by the product of its density and its specific heat capacity is thermal diffusivity. 4.Thermal expansion co-efficient: Thermal expansion coefficient is the fractional increase in the linear dimension of a sample of a substance with increase in temperature at constant pressure. 5.Specific Heat capacity:	6

		Specific *heat* is the amount of *heat* needed to raise the temperature of one kilogram of mass by 1 kelvin.	
5	b	Distinguish between thermosetting and thermoplastic polymer: **Thermoplastics** / **Thermosets** Good elasticity but depends on the type / Very poor elasticity Easily reshaped on heating / Highly intractable crosslink i.e cannot be remoulded Weak attractive forces between chains / Stronger attractive forces between chains They are soluble in organic solvents / Not soluble in organic compounds Super abrasion and dimensional stability / Better flexural and input resistance They are flexible and not rigid / They are not flexible but rigid because of network structure formed by cross-linking Softens without chemical change when heated / Undergoes irreversible change which causes it to harden or set	1 mark each for any 6 points
5	c	**Effect on Iron:** 1) chromium: Cr increases the hardenability of steel while there is a minimal effect on the ductility. Cr is normally added to steel for increasing oxidation resistance, and for improving high temperature strength. Corrosion resistance of Cr steels increases sharply at a Cr level of greater than 12 %. **2) nickel:** It increases steel strength, impact strength and toughness. It also improves toughness at low temperatures when added in small amounts. ... Ni is heat resistant, and when combined with steel, it increases the heat resistance of that steel. **3) silicon:**	2 2

		silicon is the most important alloyant because it forces carbon out of solution. ... The carbon in the form of graphite results in a softer iron, reduces shrinkage, lowers strength, and decreases density.	2
6		**Any two**	**12**
6	a	**Procedure to calculate the density of air:** Measure the mass of the empty balloon. a) Calculate mass of air in the inflated balloon in kg. b) Calculate the volume of the inflated balloon in m^3. c) Calculate the density of air in kg m^{-3}. The procedure to calculate air density given the temperature, dew point and pressure or temperature, pressure and relative humidity. The density of dry air can be calculated using the ideal gas law, $\rho_{dry\ air} = \frac{p}{R.T}$ Where: $\rho_{dry\ air}$ = Density of dry air (kg/m^3) p = air pressure (Pa) R = Specific gas constant for dry air, 287.05 J/ (kg.K) T = Temperature (°K)	6
6	b	Differentiate between addition and condensation polymerization: **Addition polymerization** | **Condensation polymerization** Produces by addition of monomers | Produces by condensation of	1 mark each

			monomers	
		Monomers must have double or triple bond	Monomers must have at least two similar or different functional group	
		No by product	Has a by-products	
		Produces thermoplastic polymers	Produces thermosetting polymers	
		Polymer is the integral multiple of monomers	Polymer is not integral multiple of monomers	
		e.g. Polypropylene	e.g. Bakelite	
6	c	**Mechanism of wet corrosion:** wet corrosion of metals occurs through electron transfer, involving two processes, oxidation and reduction.The metal, where electrons are lost, is called the anode the reaction that occurs at the cathode is not necessarily related to the material that it is made from wet corrosion therefore involves an oxidation reaction at the anode and a reduction reaction at the cathode. In the oxidation reaction metals give up electrons to become positively charged ions. Types: 1. Hydrogen evolution type of wet corrosion 2. Oxygen absorption type of wet corrosion :		2 2 2


Oxygen absorption
Water drop
O_2
Fe^{2+}
Cathode
Cathode large area
Anode small area
Iron (Fe)
Anode : $Fe \rightarrow Fe^{2+} + 2e^{\ominus}$
Cathode : $O_2 + 4e^{\ominus} + 2H_2O \rightarrow 4(OH^-)$
$Fe^{2+} + 2(OH^-) \rightarrow Fe(OH)_2$
Hydroxi
Note:- Anode action cause pitting