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	**Types of crystal structures.** (i) Atomic atructure (ii) Nano sturucture (iii) Microsturcture (iv) Macrostructure	½ mark each
1	b	**Biomaterials:** (i) A biomaterial is any material that has been engineered to interact with biological systems for a medical purpose (a therapeutic or a diagnostic) Or (ii) Materials that come in contact with tissues , blood and biological fluids and intended for use for therapeutic , prosthetic and diagnostic applications without affecting the living organism and its components.	2
1	c	**Yield stress:** (i) The yield strength or yield stress is defined as the stress at which a material begins to deform plastically Or (ii) stress is the amount of force/energy that is being exerted on a material object divided by its cross-sectional area.	2
1	d	**Dielectric strength of material:** • Dielectric strength is the ability of a dielectric material of specified thickness to withstand at high voltage without breaking down. • It is a measure of the strength of an insulating material (or a dielectric	2

		material) • A material having high dielectric strength can withstand at high voltage. • It is expressed in the unit of kV/cm.	
1	e	**Ceramics are used for following engineering applications**: 1. Cutting io and dies 2. Molten metal filters 3. Bearings 4. Sealing rings 5. Bushes 6. Fuel injection components 7. Spark plug insulators 8. Disk brakes and clutches 9. Jet turbine blades 10. Fuel cells 11. Body armour 12. Tank power trains 13. Gas burner nozzles 14. Catalytic converters 15. Catalyst supports 16. Catalyst 17. Heat exchangers 18. Reformers 19. Kiln linings 20. Crucibles for glass making 21. Firebricks for furnace and ovens	½ marks each for any 4

		22. Cylinder liners 23. Capacitors 24. Resistance heating elements 25. Flow control valves 26. Light emitting diodes , laser diodes 27. Optical communication cables 28. Heat sink for electronic parts 29. Filters 30. Rotors and gears 31. Electrode materials 32. Precise instrument parts 33. Grinding media	
1	f	**Polymerisation reaction:** (i) The process by which the monomer molecules are linked to form a large molecular weight polymer molecule is called polymerization. Or (ii) Any process in which relatively small molecules called monomers combine chemically to produce a very large chainlike molecule.	2
1	g	**The types of iron are** : 1) Pig iron 2) Wrought iron 3) Cast iron 4) Pure iron (butte iron)	½ mark each
2		**Any three**	**12**

2	a	**Thermochemistry of chemical reactions.** • Thermochemistry is the study of the heat energy associated with chemical reactions and/or physical transformations. • A reaction may release or absorb energy, and a phase change may do the same, such as in melting or boiling. • Thermochemistry focuses on these changes, particularly on the system's energy change with surroundings. • Thermochemistry is useful in predicting reactant and product quantities throughout the course of given reaction. • In combination with entropy determinations, it is also used to predict whether a reaction is spontaneous or non-spontaneous, favorable or unfavorable. • Endothermic reactions absorb heat, while exothermic reactions release heat.	4
2	b	**Thermal Expansion** : • Thermal expansion is the increase in the volume of a material a the temperature is increased. • It is usually expressed as a fractional change in dimensions of a material per unit temperature. • If a material is solid , then thermal expansion is described in terms of length , height or thickness. • Thermal expansion is said to occur when a material expands and becomes larger due to change in temperature of the solid. **Thermal stability :** • The ability of a material to withstand long time exposure to elevated/high temperatures without getting degraded.	2 2

		A thermally stable material will not be destroyed/degraded/decomposed by heat under high operating temperatures of the application.	
2	c	**Chemical reactivity of iron with acid.** Definition -Chemical reactivity is the ability of a material to combine with other materials such as water , air , acids , steam etc. (i) Iron (mild Steel) does not react with commercial grade sulphuric acid i.e. with conc. Sulphuric acid. (ii) Iron (mild Steel) reacts with dilute sulphuric acid producing ferrous sulphate as corrosion product. $Fe + 2H_2SO_4$ -----> $FeSO_4 + SO_2 + 2H_2O$ (iii) Iron (mild Steel) reacts with hydrochloric acid producing ferric chloride and hydrogen gas. $2Fe + 6HCl$ -----> $2FeCl_3 + 3H_2$	4
2	d	**Write on ductility and malleability of material.** **Ductility** • Ductility is the ability of a material to deform plastically without fracture under tensile load. • Because of this property , materials can be drawn out into fine wire without fracture. • It is therefore an indication of how soft or malleable the material is. • The ductility of steels varies depending on the types and levels of alloying elements present. • An increase in carbon , for example will increase the strength of material but decrease the ductility.	2

		Malleability • It is the ability of a material to deform plastically without fracture under compressive load. • Because of this property , metal s are hammered and rolled into thin sheets. • Malleable material can be flattened into metal leaf. • Many metals with high malleability also have high ductility. • Exmples of malleable metals are gold , aluminium , copper etc. • Gold and silver are highly malleable. • Malleable metals usually bend and twist in various shapes.	2
2	e	**Dry corrosion Mechanism**: When a metal is exposed to air it gets oxidized by loosing its valence electrons & reduction of oxygen take place M+n/4 (o^2) => M^n+ + O^2- At point of contact of m^n+ & o^2- metallic oxide will form & that metallic oxide scale forms a barrier to restrict further oxidation of inside metal . Since size of cation (M^n+) is smaller than anion . Hence cation will diffuse much faster than anion through the scale for continuation of oxidation , it can be possible if the metallic oxide barrier is sufficiently porous . The nature of oxide film plays very important role in oxidation corrosion. a. When oxide film is stable and tightly adhering , it will act as protective coating and corrosion is prevented. b. When oxide film is unstable and has tendency to decompose back to metal and oxygen , it does not go into oxidation corrosion. When film is volatile then metal surface again come into contact with air and oxidation take place d. If film is sufficiently porous then continuous oxidation take place. 2. Liquid metal corrosion - When a liquid metal is allowed to flow over solid metal at high temperature is called liquid metal corrosion. Due to this solid metal gets weak. Example- In nuclear reactor sodium metal is used as coolant & it leads	4

		to corrosion of cadmium. **OR** **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.	
3		**Any three**	**12**
3	a	**Classification of ceramics:** 1.Glasses: Glasses Ceramic glasses 2.Natural ceramics: Bones Rocks and minerals 3.Traditional ceramics: White wares Structural clay products Bricks and tiles Refractories	1 mark each for any 4

		Abrasives Cements 4.Advanced structural ceramics: Bio ceramics Automotive ceramics Nuclear ceramics Wear resistance ceramics 5.Functional ceramics: Optical ceramics Conductive ceramics Capacitors, dielectric , piezoelectric ceramics Electronic substrate , package ceramics Magnetic ceramics Oxide ceramics: aluminium oxide Magnesium oxide Zirconium oxide Aluminium titanate Silicate ceramics: porcelain Magnesium silicate Mullite Carbide ceramics: boron carbide Silicon carbide Tungsten carbide Silicon carbide: open porous SiC Dense SiC	

<table>
<tr><td></td><td></td><td>Nitride ceramics: silicon nitride
Silicon aluminium oxynitride
Aluminium nitride</td><td></td></tr>
<tr><td>3</td><td>b</td><td>Differentiate between addition and condensation polymerization:
<table>
<tr><td>Addition</td><td>Condensation</td></tr>
<tr><td>Produces by addition of monomers</td><td>Produces by condensation of monomers</td></tr>
<tr><td>Monomers must have double or triple bond</td><td>Monomers must have at least two similar or different functional group</td></tr>
<tr><td>No by product</td><td>Has a by-products</td></tr>
<tr><td>Produces thermoplastic polymers</td><td>Produces thermosetting polymers</td></tr>
<tr><td>Polymer is the integral multiple of monomers</td><td>Polymer is not integral multiple of monomers</td></tr>
<tr><td>e.g. Polypropylene</td><td>e.g. Bakelite</td></tr>
</table></td><td>1 mark each for any 4 points</td></tr>
<tr><td>3</td><td>c</td><td>Factors determining the choice of material to avoid corrosion:
1. Resistance to corrosion in given environment
2. Operating condition such as temperature, pressure and flow rate.
3. Mechanical strength
4. Ease of fabrication
5. Availability
6. First cost, maintenance cost, replacement cost
7. Expected life
8. Material selection based on sound economic analysis.</td><td>½ mark each</td></tr>
</table>

3	d	**Classification of steels:** **1. Based on carbon content**: Low carbon steel (0 %) : it is cheap, it has good tensile strength, ductility, it is malleable. Used for structural section Medium carbon steel (C=0.3-0.5 %) High carbon steel(C=0.5- 2%) **2. Based on de-oxidation practice**: Killed steel Semi killed steel Rimmed steels Capped steels	2 2
4		**Any three**	**12**
4	a	**Requirement of Thermal insulation:** 1. Thermal insulation is the reduction of heat transfer. 2. Thermal insulation is used to prevent excessive heat loss. 3. It is used to minimize the amount of heating 4. It is used to minimize fuel needed to heat it 5. It is used to keep constant temperature, **Examples:** 1. In boiler brick lining use as insulation to avoid heat loss 2. Pipe insulation is also used on water supply pipework to help delay pipe freezing for an acceptable length of time. 3. Mechanical insulation is commonly installed in industrial and commercial facilities.	½ mark each for any 4 1 mark each for any 2

		4. In refrigeration, refrigerator consists of a heat pump and a thermally insulated compartment.	
4	b	**Density of liquid:**  Density of liquid can be determined using specific gravity bottle. **Procedure:** First determine the weight of the density bottle(w1) when it's empty. Then fill it with the liquid you want to determine the density. Then determine the weight of the bottle with the liquid(w2). You already know the volume of the bottle. the density of a liquid equals the mass of the liquid divided by its volume density = m/v. = (w2-w1)/ volume	4
4	c	**Heat required** Q= m x Cp x dT = 100 x 4.18 x (100 -25) =31350 J	1 1 2
4	d	**Differentiate between metal and non metal:** **Metals** | **Non-metals** While metals are good conductors of electricity and heat | non-metals are poor conductors of electricity and heat	1 mark each for any 4 points

		metals are ductile	Non metals are not ductile
		has a metallic luster	Does not has a metallic luster
		Metals have high melting points and high boiling points as they have strong metallic bonds.	Nonmetals have high ionization energies , high electro negativities.
		Metals are hard, they can't be broken easily and require a lot of energy and strength to break.	They are very weak and brittle.
		Metals are malleable	Non metals are brittle
		Metals are opaque	Non metals are transparent
5		**Any two**	**12**
5	a	Metals: calcium , manganese, platinum, gold , iron Non- metals: hydrogen, Sulphur, silica, polyester, wood, glass, selenium	½ mark each
5	b	**Silicon carbide:** **Properties:** Density = 3.2 g/cu.cm M.P = 2800 deg C Hardness = 9 Mohs Modulus of elasticity = 6.5 High wear resistance Excellent corrosion resistance Very hard materials High thermal conductivity. **Uses:**	½ mark each for any 6

		It is used in car brakes and clutches. Ceramic plates in bulletproof vests Bearings Semiconductors wafer processing equipment Light emitting diode Cutting tools and burner nozzles.	½ mark each for any 6
5	c	**Purpose of alloy steel(any 2)** 1. To improve corrosion resistance 2. To enhance wear resistance 3. To improve toughness 4. To enhance tensile strength 5. To improve grain size **Method of preparation of alloy:** i. Fusion method ii. Powder metallurgy iii. Reduction method iv. Electro-deposition method **Fusion method**: In this method, metals are taken in a desired proportion and they are fused together in a refractory melting pot or in a brick –lined crucible. The metal with a higher melting point is melted first and then other components with lower melting points are added to the metal. The components are mixed well and are again melted. The molten mass is covered by powdered carbon to avoid oxidation of the molten mass components by oxygen. The resulting molten mass is then cooled at room temperature to turn the molten mass to solid again. **Powdered metallurgy**: It is a process in which two or more materials are first reduced to a powder and then they are mixed together by application of heat and pressure to obtain the final product.	1 mark each 4 marks for any one method.

6		**Any two**	**12**
6	a	**Corrosion** **(i)by water:** physical configuration of the system hardness of water, salts, chlorides, and dissolved gases such as oxygen, carbon dioxide, and sulphur dioxide. Presence of suspended solids in water Flow rate of water Presence of bacteria Temperature of water **(ii) by steam:** the boiler feed water contains oxygen , it enter in the boiler, and then flashed from the boiler with steam in the steam line. It also enter the steam line when air enters in it. Condensate pH is low due to carbonic acid. When bicarbonates break down in the boiler, CO2 produced which in turn form carbonic acid in steam. **(iii) by soil:** soil corrosion is a geological hazard that effect buried structures, pipelines, tanks and other objects that are in direct contact with the soil. Factors that influence soil corrosion are aeration, porosity , moisture, electrical resistivity, soil pH level, dissolved salts contents, chloride contents and soil texture. If water retention is more corrosion is more. If aeration is more corrosion is less. If dissolved salts more, conductivity is more and corrosion is more.	2 2 2
6	b	**Chemical composition of** **Stainless steel:** Min 12 % chromium	2

		12 to 30 % Cr 4 to 25 % Ni **Stainless steel 316:** Cr = 16 – 18 %, Ni = 10-14 % , Mo= 2-3 %, C= 0.08 %, Mn = 2 % , Si= 1%, **Stainless steel 314** : Cr= 23-26%, Ni= 19-22% , Si= 1.5-3 %, Mn= 2%, C=0.25 %, **Stainless steel 304**: Cr= 18-20%, Ni= 8-10.5 %, C= 0.08 %, **Tungsten steel:** 18 % Tungsten (W) 4 % Cr 1 % vanadium 0.7 % carbon Small amount of Si , S , P ,Mn , Fe.	1 1 1 1
6	c	**Effect on Iron:** **(i) 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 %. **(i) 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. **(ii) Magnesium:** Manganese:it increase tensile strength, abrasion resistance, hardenability and toughness . it decrease weldability.	2 2 2