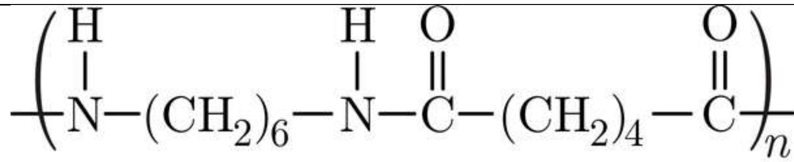
Important Instructions to examiners:

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.

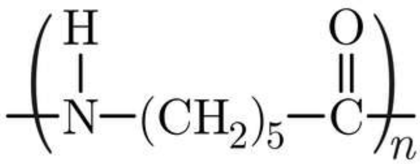
Q No.	Answer	marks
1	**Any five**	**10**
1-a	**Types of thermal insulation:** Thermal insulations are classified as – 1) Organic insulations – e.g. wool (sheep) , cork , cellulose , wood fiber , flax , cotton , hemp , phenolic foam , urea-formaldehyde foam , polyurethane foam , expanded polystyrene foam (thermocol), extruded polystyrene foam , polyethylene foam etc. 2) Inorganic insulations – e.g. aerogel , asbestos , glass wool , slag wool , rock wool , gypsum powder , foamed glass , expanded perlite , refractory bricks , ceramic wool (fiber) ,calcium silicate , vermiculat etc	1 1
1-b	**Biomaterials:** • A biomaterial is any material that has been engineered to interact with biological systems for a medical purpose (a therapeutic or a diagnostic one). • Material 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	**Thermal conductivity of engineering material:** • Thermal conductivity of engineering material is the property of a material that determines the rate at which it can transfer heat. OR • 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-d	**Thermal properties of engineering materials:(any 2)** 1. Melting point 2. Specific heat 3. Heat capacity (specific heat capacity) 4. Thermal expansion 5. Thermal conductivity 6. Thermal stability 7. Thermal shock resistance 8. Heat resistance/thermal resistance	1 mark each
1-e	**Engineering applications of ceramics: (any 2)** Ans : 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	1 mark each

	15. Catalyst supports 16. Catalyst 17. Heat exchangers 18. Reformers 19. Kiln linings 20. Crucibles for glass making 21. Firebricks for furnace and ovens 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 34. Ballistic armour 35. Bullet proof vests 36. Thread processing nozzles , oiling nozzles , rollers and twister parts.	
1-f	**Example of thermosetting polymer with its structure(any 1)** Ans: 1. Nylon 2. Nylon-6 3. Nylon-66	1 mark for name and 1 mark for structure

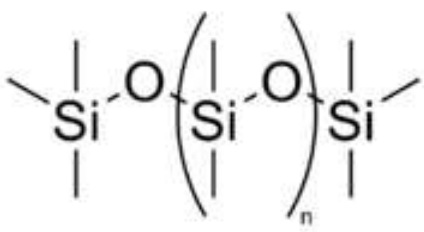


Nylon 66

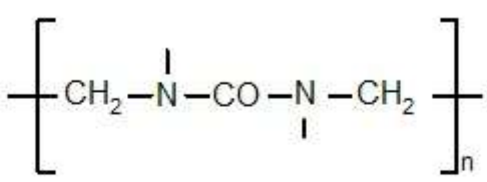


Nylon 6

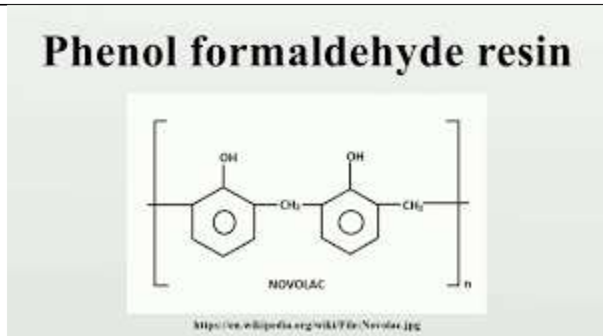
4. Silicon rubber



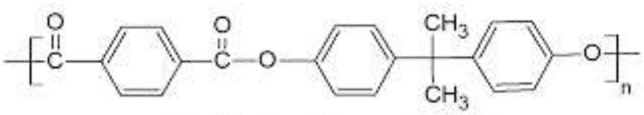
5. Urea formaldehyde



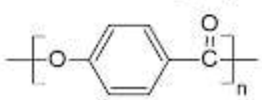
6. Phenol formaldehyde



7. Polyester

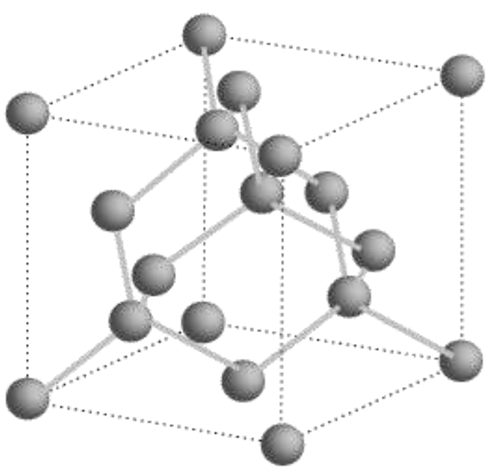


Poly(bisphenol-A-terephthalate)



Poly(4-hydroxybenzoate)

8. Silicones



1-g	**Types of steels:** Ans : The types of carbon steels/plain carbon steels or simply steels based on %	2

	of carbon content are – 1. Low carbon steel : 0.05 – 0.3 % 2. Medium carbon steel : 0.3 – 0.5 % 3. High carbon steel : 0.5 – 2 %	
2	**Any three**	**12**
2-a	**Differentiate between Nanostructure and Microstructure.**	1 mark each

Nanostructure	Microstructure
Nanostructures are structures that range between 1nm and 100nm ($1nm=10^{-9}m$) in at least one dimension.	Microstructures are structures that are revealed by a microscope of 25x or greater magnification.
A nanostructure is a structure of intermediate size between microstructures and molecular structures.	A microstructure has very small size than other structures.
Nanostructures are one dimension , two dimension and three dimension in scale.	Microstructures are one dimension in scale.
The nanostructure of a material influences physical properties of the material such as size , shape , specific surface area , aspect ratio etc.	The microstructure of a material influences physical properties of the material such as strength , toughness , wear resistance etc.

2-b	**Definition:** i) **Melting point** – • The melting point of a material is the temperature at which it changes	1

	state from solid to liquid at normal atmospheric pressure. • The temperature at which a solid material melts to become a liquid at normal atmospheric pressure. (ii) **Specific heat** – • The specific heat of a material is the amount of heat energy per unit mass required to raise the temperature of the material by one degree Celsius. (iii) **Heat capacity** – • Heat capacity is the quantity of heat energy needed to raise the temperature of a specific material by one degree Celsius. • Heat capacity is the ratio of the quantity of heat energy transferred to a material and the resultant temperature rise. (iv) **Dielectric constant** – • The dielectric constant is the ratio of the permittivity of a material to the permittivity of free space. • It is an amount measuring the ability of a material to store electrical in an electric field.	1 1 1
2-c	**Definition:** **Impact strength** – • The resistance of a material to fracture by a blow , expressed in terms of the amount of energy absorbed before fracture. • The impact strength is the ability of a material to absorb shock and impact energy without breaking /fracture. **Compressive strength** – • The compressive strength is the ability of a material to resist squeezing (compressive) load without fracture.	2 2

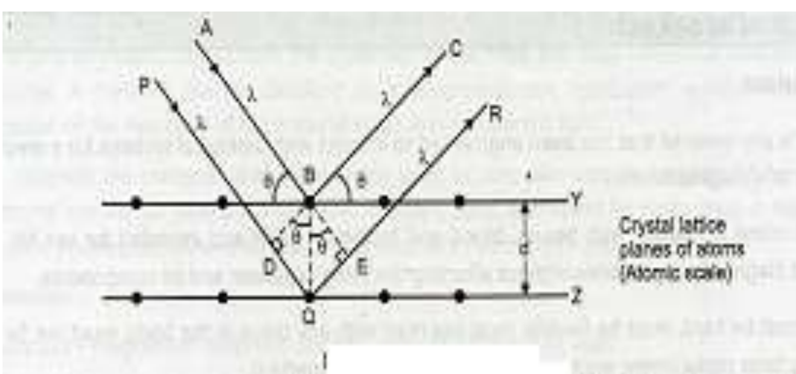
	• It is the maximum compressive stress that a material can sustain without fracture/failure , under gradually applied load.	
2-d	**Corrosion.** Definition - • Corrosion is the gradual deterioration or destruction of materials (usually metals and alloys) by chemical or electrochemical reactions with its environment. • Corrosion is defined as the gradual deterioration or destruction of a metal by chemical or electrochemical reactions with its environment. • 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. **Factors affecting rate of corrosion** – The factors affecting rate of corrosion are : A) Nature of the material (metal dependent factors) - 1) Position of the metal in the electrochemical or galvanic series 2) Purity of the metal 3) Surface of the metal 4) Relative area of cathodic and anodic part (anodeto cathode area ratio) 5) Nature of the oxide film 6) Solubility of the corrosion product 7) Physical state of the metal 8) Volatility of the corrosion product B) Nature of the environment (environment dependent factors) –	2 ½ mark each for any 4

	1) Temperature of the environment 2) pH of the environment 3) Humidity of the environment/presence of the moisture in the environment 4) Presence of impurities in the environment 5) Amount of oxygen in the environment 6) Nature of anions and cations present in the environment 7) Presence of suspended particles in the environment	
2-e	**Definition:** 1) **Ductility** • Ductility is the ability of a material to be deformed plastically without fracture under tensile strength. • Ductility is the property of material by which materials can be drawn out into fine wire without fracture. 2) **Plasticity** • The ability of a material to deform under load and retain its new shape when the load is removed. 3) **Hardness strength** • It is the resistance of a material to plastic deformation-penetration , scratching , abrasion or cutting. • The ability of a material to resist wear or abrasion and resist penetration.	1.5 1 1.5
3	**Any three**	**12**
3-a	**Differentiate between Thermosetting and Thermoplastic polymers**:	1 mark each for any 4

Thermosetting	**Thermoplastic**
Polymers which once mould /shaped do not soften when	Polymers whose shape can be changed on application of

	heated and thus cannot be reshaped	heat are k/as thermoplastic polymers	
	It can be heated and shaped once.	These are soften by heating , shaped when hot, harden when cooled, reshaped when heated again.	
	It can be decamped when reheated. No plasticity	These are soften for no. of times on heating without change in their properties.	
	e.g. epoxy resins, urea formaldehyde etc	e.g. polyethylene, polypropylene etc	
	They have 3 dimensional cross linked structure	They have long chain linear structure	
	Produced by condensation polymerization process	Produced by addition polymerization process	
	High molecular weight	Low molecular weight	
	These are hard, more brittle and strong	These are soft, less brittle and weak	
	Monomer used in this polymer is tri, tetra or poly functional.	Monomer used in this polymer bi functional.	
3-b	**Classification of metals:** Metals: 1. Ferrous. example: cast iron, stainless steel 2. Non ferrous. example: Al and its alloys, Cu and its alloys		1

	Classification of non metals: 1. Plastic 2. Rubber 3. Glass 4. Ceramics e.g. wood, asbestoses etc.	1
	Uses of metals: metals are used for MOC in steam boiler and steam pipeline it is used in storage and transporting it used for distillation column, storage tank, pump, pipe etc.	½ mark each for any 2
	Uses of non metals: non-metals are used for gaskets. It is used for seals, bushes , glands etc. Used for vessel and reaction kettle lining. Etc.	½ mark each for any 2
3-c	**Corrosion in alkaline medium**: Cathodic reaction is : absorption of oxygen $O_2 + 2 H_2O + 4 e^- \rightarrow 4 OH^-$ Corrosion is less in alkaline medium Example of alkaline medium is NaCl solution, e.g. a piece of iron is immersed in sodium chloride solution $Fe \rightarrow Fe^{2+} + 2 e^-$ $NaCl \rightarrow Na^+ + Cl^-$ $\frac{1}{2} O_2 + H_2O + 2e^- \rightarrow 2 OH^-$ $Na^+ + OH^- \rightarrow NaOH$ $Fe^{2+} + 2Cl^- \rightarrow FeCl_2$	4
3-d	**Composition of SS-304**:	

	18 – 20 % Cr, 8 – 10.5 % Ni, 0.08 % max C, small amount of Mn, Si, P,S and the balance is Fe. **Properties:** Density= 8000 Kg/ cu. m MP. : 1450 deg. C Thermal conductivity: 16.2 W/(mK) Good weld ability Good heat resistance Good drawing and forming properties	2 2
4	**Any three**	**12**
4-a	**Crystal structure of glass by Bragg's law:** The general relationship between the wavelength of the incident x ray, angle of incidence and spacing between the crystal planes of atoms is known as Braggg's law, expressed mathematically as $2d \sin \theta = n\lambda$ Where n is an integer, λ is the wavelength of the incident x ray, d is the interplanar spacing of the crystal or distance between the layers of atoms and θ is the angle of incidence.  1. Consider that the x ray of wavelength λ is incident on a crystal at an angle θ . The incident rays AB and PQ after reflection from the crystal	4

lattice planes Y and Z travel along BC and QR

2. Let the spacing between the crystal lattice planes of atoms be d
3. Draw perpendiculars BD and BE from point B on PQ and Qr respectively. BD and BE are the perpendiculars from point B on lines PQ and PR respectively.
4. Thus the path difference between the two waves ABC and PQR is DQ + QE. The path of the wave PQR is longer than the path of the wave ABC by DQ+QE.

In the Δ DBQ, $\sin\theta = DQ/BQ$

Therefore $DQ = BQ \sin\theta$

In the Δ EBQ, $\sin\theta = QE/BQ$

Therefore $QE = BQ \sin\theta$

Path difference between two rays = DQ+QE

$= BQ \sin\theta + BQ \sin\theta = 2\, BQ \sin\theta$

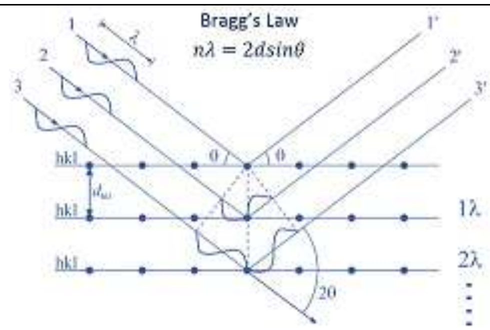
$= 2d \sin\theta$ since BQ =d

If the path difference $2d \sin\theta$ is equal to the integral multiple of wave length of x ray, i.e. $n\lambda$, then constructive interference will occur between the reflected rays and they will reinforce each other and consequently the intensity of reflected beam is maximum.

Thus, for constructive interference to occur:

$2d \sin\theta = n\lambda$

This is known as Bragg's law.

	 Bragg's law path difference	
4-b	**Chemical reactivity of iron with air:** Chemical reactivity is the ability of a material to combine with the other materials . Chemical reactivity of iron / mild steel (MS) with air MS react with air to form iron oxide, Fe_2O_3 . MS react with oxygen from air in the presence of moisture or dissolved oxygen from water to produce hydrated iron oxide $Fe_2O_3 .xH_2O$ (called brown rust). The oxide film is formed is non-protective and it flake-off from the surface thereby exposing the fresh metal surface for further reaction with air and water.	4
4-c	$Q = m \times Cp \times (T_2 - T_1)$ $= 50g \times 4.18\ J/gK \times (373 - 273)\ K$ = **20900 j**oules	2 2
4-d	**Classification of ceramics:** **1.Glasses:** Glasses Ceramic glasses **2.Natural ceramics**: Bones Rocks and minerals	1 mark each for any 4 with one example

	3.Traditional ceramics: White wares Structural clay products Bricks and tiles Refractories 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	
5	**Any two**	**12**
5-a	(see table below)	1 mark each for 5 points 1 mark for example.

Addition polymerization	**Condensation polymerization**
1)the polymerization reaction involves the joining of unsaturated monomers by breaking of bonds in a chain like manner without loss of	Many monomers molecules join together to form the polymer with the loss or elimination of a small by products such as water or

	any by products is k/as addition polymerization.	methanol is k/as condensation polymerization	
	2)monomers must have at least double or triple	Monomers must have at least two dis similar of different functional groups.	
	3)monomers add to produce polymers	Monomers are condensed to produce polymers	
	4)no by product is form	By product is formed such as water or methanol	
	5)it produces thermoplastics	It produces thermosetting polymers	
	Example: pvc(poly vinyl chloride)	Example: formaldehyde	

5-b	**Industrial importance of:** **i) Silicon carbide:** 1. It is used in car brakes and clutches. 2. Ceramic plates in bulletproof vests 3. Bearings 4. Semiconductors wafer processing equipment 5. Light emitting diode 6. Cutting tools and burner nozzles. ii) **Aluminium oxide**: 1. Bearing liners and seals 2. Cutting tools 3. Artificial bones and teeth 4. Engine and turbine parts 5. Thermometry sensors	½ mark each 3

5-c	**Classification of alloy steels** Based on its composition: 1) Simple alloy steels: It is the alloy steel containing one alloying element eg nickel steel 2) Quaternary alloy steel: It is the alloy steel containing two alloying elements eg chromium and vanadium 3) Complex alloy steel: It is the alloy steel containing more than two alloying elements eg. High speed tool steel	2 2 2
6	**Any two**	**12**
6-a	**Prevention and control of corrosion:** 1.Material selection and choice of materials 2.Proper design and fabrication of components 3. Use of high purity metals: The impurities present in a metal cause heterogeneity and form tiny electrochemical cells with rest of the metal. Due to this, metal undergoes corrosion at the region where impurities are present. Pure metal does not corrode. 4.Specific heat treatment 5.Modification of corrosion environment 6. Use of alloying: Corrosion resistance of many metals can be increased by alloying them with suitable alloying elements. 7. Use of inhibitors: Inhibitors are organic chemicals which are added in small amounts to a corrosive medium in order to reduce its corrosive effect. Usually they form and maintain a protective film on the metal surface and thus acts as a barrier for further corrosion. 8.Cathodic protection (electrochemical protection): In this, the metal is forced	1 mark each for any 6 points

	to behave like a cathode thus protecting it from corrosion. This is achieved by supplying electrons to the metal surface to be protected. Addition of electrons to the metal suppresses its dissolution into metal ions. Different types are: Sacrificial anodic method Impressed current method 9.Use of protective surface coatings: Protective coatings provide a continuous physical barrier between the surface to be protected and the environment.These are classified as: Metallic coatings Inorganic coatings Organic coatings	
6-b	**Effect on iron:** i) Copper: it improves the resistance to atmospheric corrosion. It strengthens steel. It may be added to improve formability. It improves pains adhesion ii) Phosphorus: it is considered as the undesired impuries in steel because of its embrittling effect. It improves strength but at the same time decrease the ductility .it is upto 0.04 % by weight. iii) Manganese:it increase tensile strength, abrasion resistance, hardenability and toughness . it decrease weldability.	2 2 2
6-c	**Cladding mechanism**: Cladding is the bonding together of dissimilar metals. It is different from fusion welding or gluing as a method to fasten the metals together. Cladding is often achieved by extruding two metals through a die as well as pressing or rolling sheets together under high pressure. laser cladding is a method of depositing material by which a powdered or wire feedstock material is melted and consolidated by use of a laser in order to coat part of a substrate or fabricate a near-net shape part .	2

	It is often used to improve mechanical properties or increase corrosion resistance, repair worn out parts and fabricate metal matrix composites. **Process:** The powder used in laser cladding is normally of a metallic nature, and is injected into the system by either coaxial or lateral nozzles. The interaction of the metallic powder stream and the laser causes melting to occur, and is known as the melt pool. This is deposited onto a substrate; moving the substrate allows the melt pool to solidify and thus produces a track of solid metal. This is the most common technique, however some processes involve moving the laser/nozzle assembly over a stationary substrate to produce solidified tracks..	3
	Advantages • Best technique for coating any shape . • Particular dispositions for repairing parts . • Most suited technique for graded material application. • Well adapted for near-net-shape manufacturing. • Low dilution between track and substrate • Low deformation of the substrate and small heat affected zone. • High cooling rate . • A lot of material flexibility (metal, ceramic, even polymer). • Built part is free of crack and porosity. • Compact technology.	1